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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 159.

A. C. TRUE, Director.

A DIGEST OF JAPANESE INVESTIGATIONS
ON THE NUTRITION OF MAN.

BY

KINTARO OSHIMA,

*Director of the Hokkaido Agricultural Experiment Station,
Sapporo, Japan.*WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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(2)

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 26, 1905.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 159 of this Office, a digest of Japanese experiments on the nutrition of man, prepared by Prof. Kintaro Oshima, director of the Hokkaido Agricultural Experiment Station, Sapporo, Japan.

Professor Oshima made a special study in Europe and the United States of the experimental methods followed in nutrition investigations, the results obtained by western investigators, and related questions. About two years were spent in the United States, and during this time he was intimately associated with the nutrition investigations carried on under the auspices of this Office, and the present compilation was made in accordance with plans prepared by Prof. W. O. Atwater, chief of nutrition investigations of the Department of Agriculture.

Appreciating fully the importance of proper nutrition from the standpoint of economy and public health, the Japanese have for a number of years been actively engaged in experiments which have to do with the nutritive value of foods, and food requirements under different conditions as regards occupation and environment, and have also studied many of the more technical questions connected with the general theories of nutrition. Much of the information which they have accumulated is published in the Japanese language and hence available to few students outside of Japan. Professor Oshima has made a special effort to gather as much as possible of this and all other material published by Japanese investigators in the period covered by his compilation, and it is believed that the experimental data and summaries presented contain much that will prove of general use to students and investigators of nutrition problems.

In the final preparation of this bulletin for publication important service was rendered by R. D. Milner, of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction.....	9
Dietary studies.....	10
Analyses of food materials.....	12
Digestion experiments.....	12
Food of the army and navy.....	13
Investigations by the navy medical bureau	13
Investigations by the army medical bureau	14
Miscellaneous investigations.....	15
Scope and plan of the compilation.....	16
Japanese food materials.....	18
Food staples and ways in which they are used.....	18
Preparations of fish.....	19
Dried bonito.....	19
Kamaboko and hampen.....	20
Preparations of cereals.....	20
Bread.....	20
Fu.....	20
Macaroni and vermicelli.....	20
Sobakiri.....	21
Mochi.....	21
Ame.....	22
The soy bean and its preparations.....	23
Tofu.....	26
Miso.....	28
Shoyu.....	30
Natto.....	33
Miscellaneous food products.....	34
Dried algæ.....	34
Bamboo shoots.....	34
Kampyo.....	35
Konnyaku.....	35
Onions.....	35
Radishes.....	35
Alcoholic beverages.....	36
Composition of Japanese food materials.....	36
English equivalents of Japanese names.....	37
Methods of analysis.....	38
Food consumption in Japan.....	45
Nature of the daily food.....	45
Preparation of daily food.....	45
Studies of food consumption.....	47

Food consumption in Japan—Continued.

	Page.
Dietary studies.....	54
Dietary studies with medical students and a nurse (Nos. 1-3).....	54
Dietary studies with officers and marines (Nos. 4-7).....	56
Dietary study with military cadets (No. 8).....	59
Dietary studies with prisoners (Nos. 9-11).....	60
Dietary studies with students and business clerks (Nos. 12-15).....	61
Dietary studies with professional men (Nos. 16 and 17).....	66
Dietary study with marines (No. 18).....	66
Dietary studies with people representing different classes (Nos. 19-21)....	67
Dietary study with a school business agent (No. 22).....	69
Dietary study with a physician (No. 23).....	71
Dietary study with a merchant (No. 24).....	71
Dietary study with a man at hard labor (No. 25).....	73
Dietary study with a jinrikisha man (No. 26).....	74
Dietary studies with students (Nos. 31-33).....	77
Dietary study with marines (No. 34).....	80
Dietary studies with groups of soldiers (Nos. 43-52).....	80
Dietary studies with military cadets (Nos. 53-58).....	82
Dietary study with military nurses (No. 66).....	84
Dietary studies with individual soldiers (Nos. 74-92).....	84
Dietary studies with military nurses (Nos. 93 and 94).....	89
Dietary studies with marines (No. 95).....	90
Dietary study with coal miners (No. 96).....	91
Dietary studies with military patients (Nos. 97 and 98).....	93
Dietary studies with native Formosans (No. 99).....	94
Dietary study with a military colonist (No. 100).....	95
Dietary study with prisoners (No. 101).....	96
Dietary study with an army surgeon (No. 102).....	97
Studies of navy rations. Peace footing (Nos. 103-121).....	98
Dietary experiments.....	101
Experiments with a physician (Nos. 27-30).....	101
Experiments with professional men (Nos. 35-42).....	105
Experiments with a laboratory servant (Nos. 59-65).....	111
Experiments with rice and rice-barley diets (Nos. 67-73).....	113
Summary and discussion.....	114
Professional and business men's dietaries.....	115
Students' dietaries.....	117
Dietary studies with men at hard work.....	119
Dietary studies in the army.....	121
Present Japanese army ration.....	123
Dietary studies in the navy.....	124
Results of miscellaneous dietary studies.....	126
Deductions.....	128
Adequacy of the diet.....	128
Proportions of total nutrients in Japanese mixed diet supplied by different groups of food materials.....	130
The Japanese as vegetarians.....	133
Importance of rice in the Japanese diet.....	134
Importance of legumes in the Japanese diet.....	137

	Page.
Digestibility of Japanese food materials.....	137
Digestion experiments.....	144
Digestion experiments with cereals, legumes, and fish (Nos. 1-12).....	145
Digestion experiments with mixed diet (Nos. 13-15).....	151
Digestion experiments with rice and tofu (Nos. 16 and 17).....	152
Digestion experiment with rice and tofu (No. 18).....	153
Digestion experiment with mochi (No. 19).....	154
Digestion experiment with rice (No. 24).....	156
Digestion experiments with mixed diet (Nos. 25-27).....	156
Digestion experiments with rice, rice-barley, and bread rations (Nos. 51-69).....	158
Digestion experiments with mixed diet (Nos. 70 and 71).....	163
Digestion experiments with milk and "Health" (Nos. 72 and 73).....	164
Digestion experiment with frozen mochi (No. 74).....	165
Digestion experiment with buckwheat flour (No. 75).....	166
Digestion experiments with wheat and buckwheat preparations (Nos. 76-80).....	167
Digestion experiments with single food materials (Nos. 81-98).....	168
Digestion experiments with sweet potatoes (Nos. 99 and 100).....	173
Digestion experiment with an army ration (No. 101).....	174
Digestion experiments with rice gruel (Nos. 102-104).....	175
Digestion experiments with vegetable foods (Nos. 105-112).....	176
Digestion experiments with rice in combination with other food materials (Nos. 113-125).....	178
Incomplete digestion experiments.....	184
Summary and discussion of results.....	187
Experiments with animal food.....	187
Fish.....	187
Experiments with cereals.....	188
Rice:.....	189
Barley.....	189
Other cereals than rice and barley.....	190
Experiments with legumes.....	190
Experiments with starches and konnyaku.....	193
Experiments with vegetables.....	193
Experiments with various diets.....	195
Rice and barley diet.....	197
General summary of digestibility.....	198
Metabolic products in feces.....	199
Artificial digestion of feces.....	200
Corrections for metabolic products in feces.....	203
Digestibility of the nutrients of different classes of food materials in Japanese mixed diet.....	205
Experiments on the metabolism of nitrogen.....	209
Fuel value of nutrients in Japanese diet.....	216

A DIGEST OF JAPANESE NUTRITION INVESTIGATIONS.

INTRODUCTION.

Following the Restoration in Japan, and the reorganization of the Government in 1867, the characteristic features of western civilization were eagerly sought and introduced into the country. Men of science and experience from different parts of the world have been employed by the Government to advise and assist in the development of political and educational institutions, and to engage in imparting western knowledge to the young minds of Japan. It has also been the policy of the Government to send abroad responsible officials and others to study carefully the political and social organizations and institutions in different countries, to learn the best methods of scientific enterprises, and thus to avail themselves of the fruits of study and experience of other lands, to the advantage of similar institutions in Japan. Among the many new ideas and suggestions thus obtained by coming in contact with Western peoples and civilization were those concerning methods of living, especially as regards the diet of the Japanese. It began to be questioned whether the dietary customs of the people were the best for them, and whether there was not something to be learned in this respect from the West. Indeed, the question of how to improve the physique of the Japanese had attracted the serious consideration of the thinking men at the time. The improvement of the national diet was a very popular subject of public lectures, and diverse views and opinions were exchanged by the scientists in the country.

Actual scientific investigation of the subject of nutrition in Japan began comparatively early in the new régime, the first results being published in 1882 (see p. 54). Prominent among the earlier investigators were German scientists in the employ of the Japanese Government in various institutions, and to them is due very largely the credit for undertaking the first investigations; but even in these studies Japanese scholars were directly interested, several having assisted in carrying out the details of the work, and very soon native investigators themselves carried on more extended researches. Scientists connected with different educational and other institutions made investigations of various problems concerned in the nutrition of the Japanese.

The more important lines of investigation were dietary studies, determinations of the chemical composition of Japanese food materials, digestion experiments, and nitrogen metabolism experiments, but in addition to these a considerable amount of research which was more or less closely related to the study of the problem of nutrition, though more narrowly physiological in character and purpose, was also conducted. The following brief résumé, which is not altogether complete, will afford an indication of the development of work along these lines.

DIETARY STUDIES.

The earliest nutrition investigation in Japan consisted of dietary studies. The first of these, so far as the compiler could discover, was undertaken by B. Sheube,^a a German physician connected at the time with the Medical School at Kyoto, assisted by Kayama and Honda. They studied the dietaries of two medical students and a nurse. The results of these studies were published in 1882.

From the results obtained in these studies, and from his personal observations, the author concluded that the food of the Japanese contained on the whole a sufficient amount of nutrients to meet the physiological demands of the people. Objections to his general conclusion were made by some investigators, on the ground that the dietaries which he studied contained considerable amounts of animal foods, and therefore could not well represent the conditions of the majority of the Japanese people, who lived almost if not entirely on a vegetable diet.

Sheube also first pointed out that the intestine of the Japanese is about one-fifth longer than that of Europeans in proportion to the height of the body, and he inferred from this that in consequence the Japanese have a larger capacity than Europeans for the digestion of rice and similar vegetable food products. Results of digestion experiments with Japanese conducted by later investigators, however, seem hardly to sustain this view.

Eijkmann, Tahara, and their associates, who were connected with the Sanitary Laboratory of the Department of the Interior at Tokyo, made several dietary studies (see p. 48), the results of which were published in 1886 and 1887. In the dietaries which they studied they usually found small amounts of protein and fat, and they called attention to the need of improving the diet of the Japanese in these respects.

Tahara^b proposed the following dietary standard for Japanese performing a moderate amount of muscular work: Protein, 96 grams; fat, 20 grams; carbohydrates, 450 grams; fuel value, 2,380 calories; nutritive ratio, 1 : 5. He based his figures on Voit's

^a Mitt. Deut. Gesell. Natur- u. Völkerk. Ostasiens, 3 (1882), No. 27, p. 294.

^b Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1887, No. 2.

standard, making allowance for the smaller average weight (see p. 117) of the Japanese, and compensating for the small amount of fat ordinarily present in the Japanese dietaries by an increase in the quantity of carbohydrates. Tahara advocated strongly an improvement of the diet in accordance with his standard, and suggested several menus for dietaries which would furnish the proposed amounts of nutrients.

Kellner, who was then in charge of the Agricultural Chemical Laboratory at Komaba, near Tokyo, in cooperation with his assistant, Y. Mori, attempted to throw light upon the problem of the nutrition of the Japanese. These investigators studied not only the amounts of nutrients in food consumed, but also the digestibility of the nutrients and the relation between income and outgo of nitrogen in the body. (See pp. 48, 139, and 210.) Their results were published in 1887. They experimented with diets which they believed to be typical of those of three different classes of people in Japan. With the mixed vegetable diet, which was taken as representative of the dietary of the poor farming and laboring classes, the subject of the experiment could not obtain nitrogen equilibrium even at the end of six days. In their opinion such a diet was not sufficient to meet the demands of the organism when external work is performed. They recommended the use of fish and of preparations of legumes to increase the amount of protein in the diet. The results of their experiments were the subject of considerable discussion at the time.

The amount of protein in the diet was the most important of the topics taken up in the discussion. Several series of experiments were conducted by Nakahama and Kumagawa while they were studying in Germany, and by Amaya and Kirisawa at Sendai, with special reference to the requirement of protein. Nakahama,^a while at the University of Leipzig (1888), determined the amount of nitrogen in the urine and feces of 13 Saxon laborers in Leipzig. From the results of these studies he calculated that the diet consumed by the subject supplied on the average 85 grams of protein per man per day. His conclusion was that Voit's standard for the requirement of protein was too high. Kumagawa (1889), at the Pathological Institute of the University of Berlin, and Amaya and Kirisawa (1891), at the Medical College of Sendai, conducted dietary studies and digestion and nitrogen metabolism experiments (see pp. 48, 139, and 210). They found that 52 to 56 grams of protein was sufficient to maintain nitrogen equilibrium in the bodies of the subjects concerned, provided the diet supplied a sufficient amount of energy. In the opinion of Kumagawa the failure to maintain nitrogen balance with vegetable diet in the experiments conducted by Kellner and Mori was due to an insufficient amount of energy rather than of protein.

^a Arch. Hyg., 8 (1888), p. 78.

The natural inference from the results of these experiments was that the Japanese dietaries, supplying 60 to 70 grams of protein per day and sufficient energy as found by Tahara and others, could hardly be called imperfect or insufficient from a physiological standpoint.

Tsuboi, at the Hygienic Institute of Tokyo University, made several dietary studies (see p. 48) of men of professional and laboring classes. The results were published in 1888-1890. In some cases the urine was collected and nitrogen determined. In three other individual studies the digestibility of protein and the metabolism of nitrogen were also studied.

Baelz,^a a professor connected with the medical faculty of Tokyo University, frequently discussed the food and physical constitution of the Japanese in general, though no investigations by him were found on record. It was his opinion that the Japanese subsist on a mixed diet so far as their means allow, and that their diet is sufficient from a physiological standpoint. Either from necessity or from habit, the large majority of the people live mainly on a vegetable diet, but turn readily to the mixed animal and vegetable diet when opportunity is afforded. He did not maintain that the vegetable diet is preferable, but believed that it is possible to maintain good physical condition and perform large amounts of work while living upon it. In his opinion Voit's standard for protein per day for a working man (120 grams) is intended rather for Europeans than for Japanese.

ANALYSES OF FOOD MATERIALS.

A considerable amount of information regarding the composition of Japanese food materials was obtained from the analyses of foods used in dietary studies and digestion experiments, but much more from a special study of the subject. When the Japanese Department of the Interior established the Sanitary Laboratory, immediate attention was given very largely to analyses of Japanese food materials and to dietary studies of people in different circumstances. It is interesting to note that the first and second bulletins issued by the laboratory (1886-87) consisted wholly of the results of the analyses of food materials and of dietary studies by Eijkmann, Tahara, and associates.

DIGESTION EXPERIMENTS.

No experimental data upon the digestibility of Japanese food materials existed until Osawa conducted a series of digestion experiments at the Physiological Institute of Tokyo University, and published his results in 1887. These investigations contributed very materially to a knowledge of the physiological value of Japanese foods.

^a Mitt. Deut. Gesell. Natur- u. Völkerk. Ostasiens, 4 (1887), No. 36, p. 295; also Berlin. Klin. Wehnschr., 38 (1901), No. 26.

One practical and very important result of the experiments was a comparison of the actual nutritive value of barley and rice. A more general use of barley in place of rice had been recommended, because the protein content of the former is somewhat the larger, but Osawa's experiments demonstrated that the digestibility of the protein of barley was very low.

Several other digestion experiments were conducted later in the laboratory of Professor Osawa under his direction. A considerable amount of study of the digestibility of food was also carried out in other connections as mentioned below.

FOOD OF THE ARMY AND NAVY.

With the new organization of the imperial army and navy the problem of nutrition became very direct and serious. Here were large numbers of men to be fed at public expense. It was desired to provide them with the best ration possible, that is, the one that would keep them in the most efficient condition, and at the same time to consider the question of economy. For solution of the problem the experience of other countries was consulted, and a large number of investigations were carried out by the medical bureau of the army and the navy. Indeed, these comprise a very large proportion of the Japanese nutrition investigations found on record at the time the present compilation was made (1902).

INVESTIGATIONS BY THE NAVY MEDICAL BUREAU.

The prevalence of kakke, or beriberi, in the navy turned the attention of many medical specialists toward the problem of nutrition. While no satisfactory explanation as to the cause of the disease was offered, it was generally believed that there was some very close relation between the disease and the rice diet. The marines in the imperial navy were affected with the disease to an alarming extent. During the six years from 1878 to 1883, inclusive, over 32 per cent of the total number of marines suffered from it. This large proportion seriously interfered with the management of the fleet and threatened its efficiency in time of need; consequently the medical authorities of the navy decided to make a thorough investigation of the subject.

Special attention was directed to the ration of the navy, and a long continued dietary study (see p. 56) was made on the battle ship *Ryujō*, which left Japan in December, 1882, for a voyage to New Zealand, Chile, Peru, and Hawaii, and returned in September, 1883. On the return of the battle ship a special committee was appointed to investigate and discuss the results of the dietary studies and the possibility of relation between the diet and the disease. It was found in this particular case that the largest proportion of patients suffering from kakke was among the marines, whose ration contained the lowest

amount of protein and the widest nutritive ratio (1:7). The facts revealed in this study, combined with the experiences during the preceding years, convinced the committee of the urgent necessity of an improvement in the ration with special regard to the amount of protein, and also of providing better sanitary conditions for the marines in general.

One outcome of these investigations was the passage of the food supply act of the navy in 1884. The ration provided in accordance with this act was sufficient to furnish an abundance of protein and energy. From time to time modifications in the ration allowance have since been made as experience and the progress of science have suggested (see p. 98). Several dietary studies on individual battle ships have since been carried on by navy surgeons. Following the change of ration in 1884 the prevalence of the disease was very materially diminished, and at the end of three years cases of kakke were practically unknown among the marines.

In effecting reforms and improvements of the navy ration there were many difficulties to be overcome. The credit for the successful achievement is largely due to the steady and untiring efforts of Surgeon-General Takagi.

INVESTIGATIONS BY THE ARMY MEDICAL BUREAU.

The medical bureau of the army soon realized the necessity and importance of studying the army ration from both a physiological and an economic standpoint. A special commissioner was sent to Europe to make investigations on the subject. R. Mori,^a while at Munich in 1886, suggested the following standards for army rations for the Japanese:

TABLE 1.—Standards for army rations.

	Pro- tein.	Fat.	Carbohy- drates.	Fuel value.
Peace footing.....	100	20	500	2,500
Maneuver footing.....	110	23	520	2,745
War footing.....	120	25	560	2,965

The ration was to consist of rice, fish, miso, and tofu, with the addition of green vegetables and pickles. In the years 1888 and 1889 a large number of dietary studies were made with different groups of the Japanese imperial army, and in army schools. In the Army Medical College more specific study of the diet of the army was also carried on under the directorship of R. Mori, with Oi, Iishima, and Taniguchi as associates. Special attention was given to the comparative merits of the so-called European ration, in which bread replaced a large part of the rice, the Japanese rice ration, and the rice-barley

^a Arch. Hyg., 5 (1886), p. 333.

ration. These investigations comprised not only dietary studies, but also digestion and nitrogen metabolism experiments. The results obtained were published in a bulletin of the Army Medical College in 1892.

A large number of digestion experiments on single food materials was also conducted in the laboratory of the Army Medical College and published in the bulletins of the college. Several individual dietary studies were also made by army surgeons in different parts of the country during the years 1894-1899.

MISCELLANEOUS INVESTIGATIONS.

A number of investigations were made in which the amount of nitrogen in the urine eliminated was determined, for the purpose of ascertaining the approximate rate of protein katabolism in the body. At the Physiological Institute of Tokyo University Kajita^a collected the urine of 41 persons of different occupations and circumstances for periods of 3 to 7 days, and determined the proportions of N, P₂O₅, SO₃, Cl, etc. The results were published in 1890. Similar investigations were made by Funaoka and Katsuyama^b at the medical school at Okayama. Furukawa^c studied the effects of different diets on the composition of urine.

Osawa^d collected the urine and feces of seven persons who were fasting at the temple of Narira in the province of Shimosa. He determined N, P₂O₅, SO₃, Cl, K₂O, Na₂O, CaO, MgO, aceton, albumin, phenol, and indican.

Kajita^e made artificial digestion experiments with several single food materials and compared the results with those of experiments made with men. The results were not at all satisfactory.

Miura^f made a series of experiments at Berlin in 1891 to investigate the influence of alcohol upon nitrogen metabolism. The specific purpose of his investigation was to find out whether or not alcohol acts as a protector of protein.

Undoubtedly other investigations of special physiological problems that are more or less closely related to that of nutrition have also been made.

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 4 (1890), p. 275. Also Chugai Iji Shimpo (Med. News, foreign and domestic), 1890, No. 250, p. 853.

^b Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 15 (1901), p. 8.

^c Chugai Iji Shimpo (Med. News, foreign and domestic), 1888, Nos. 197, 199, and 200.

^d Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 3 (1889), pp. 487, 551, and 646.

^e Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 4 (1890), pp. 550-554; 676-679.

^f C. von Noorden: Beiträge zur Lehre von Stoffwechsel des gesunden und kranken Menschen, 1892, No. 1, p. 1. Also U. S. Dept. Agr., Office of Experiment Stations Bul. 45, p. 49.

SCOPE AND PLAN OF THE COMPILATION.

In preparing the present publication the object has been to include as many as possible of the investigations on the nutrition of the Japanese, comprising studies of the chemical composition of Japanese food materials, dietary studies and feeding experiments, digestion experiments, and nitrogen metabolism experiments, that had been completed and reported up to the time when this compilation was undertaken (1902). No attempt was made, however, to collate the results of special investigations which, though interesting in connection with a study of nutrition, are more narrowly physiological in nature.

In collecting the material most of the leading Japanese journals of medicine and hygiene, and the official reports of the Japanese Departments of Agriculture and Commerce, of the Interior, of the Army, and of the Navy, were examined. Several foreign journals, chiefly German, were also consulted. Some of the earlier investigations by Germans in Japan, and those by Japanese in Germany, were published originally in German, though in most instances they were later published in Japanese also. The results of most of these Japanese nutrition investigations reported in foreign journals have previously been abstracted in bulletins of this Office.^a These are included in the present compilation simply to make it as complete as possible up to the time it was prepared. While the compiler can not be positive that he succeeded in finding all publications containing accounts of Japanese investigations, he is very confident that few, if any, have escaped notice.

In compiling the material included in the present bulletin the plan has been to arrange similar investigations in separate groups. In some cases the same investigation comprised two or more kinds of inquiry, e. g., in connection with dietary studies analyses of food materials were commonly made, and sometimes the digestibility of the diet was also determined. In such cases each kind of data has been included in its appropriate section. Some sections are further subdivided into groups in which the inquiries made for a similar purpose are brought together. For convenience the studies in each section are numbered in series, in chronological order, a new series beginning with each section.

The details are given, wherever possible, as completely as seemed necessary to afford a clear understanding of each investigation. In some cases the original accounts were very brief and condensed. Whenever further information seemed desirable an attempt was made to get it by correspondence with the investigator, generally

^a U. S. Dept. Agr., Office of Experiment Stations Buls. 21 and 45.

with success, but in a few instances the only information that could be obtained was that in the published account.

On the other hand, the compiler has added considerable discussion of the food materials and dietary habits of the Japanese, and other topics, which may help to a better understanding and interpretation of the investigations; and in each section the results of the investigations there included are summarized and briefly discussed, and some of the more obvious deductions are pointed out.

A section which seems especially important to the compiler has been added. This discusses the fuel value of the nutrients of the Japanese diet. In none of the Japanese investigations included in this digest was the direct determination of energy attempted, but in some studies the energy value of the diet was computed by use of factors proposed by Rubner^a in 1885. It seems probable, however, that neither these factors, nor those more recently proposed by Atwater and Bryant^b, are strictly applicable to the nutrients of the Japanese diet, because of differences in digestibility. On the basis of the results of the investigations included in this compilation and the determinations of heats of combustion made elsewhere, tentative factors for the fuel value of nutrients in the Japanese diet have been proposed, and used in calculating the fuel value of the Japanese dietaries.

In computing their results many of the investigators used three or even more decimal figures. It is believed, however, that the experimental methods in such investigations are not accurate enough to warrant the numerical expression of results with so many decimals. In the case of dietary studies in which the composition of food materials is assumed, the use of even one decimal figure seems to imply a greater accuracy than can be claimed for such results. However, it is a common custom to use one decimal in expressing the results of dietary studies, whether the food materials were carefully sampled and analyzed or their composition was assumed, and this custom has been followed in the present compilation, the first decimal figure being increased by 1 if the second was 5 or over in the original. In summary tables the decimals may be discarded entirely. In the results of digestion experiments two decimals are commonly used, and such is the case here, unless the original report gave only one. Sometimes this change in decimals causes a slight discrepancy between the coefficients in the tables of this compilation and those in the original account, but usually the difference is much too small to be of any significance. In all other cases the results as given in the original

^a Ztschr. Biol., 21 (1885), p. 377.

^b Connecticut Storrs Station Rpt. 1899, p. 73.

report have been retained here, unless there was some special and obvious reason for a change or correction.

JAPANESE FOOD MATERIALS.

The most important matter included in the section dealing with Japanese food materials is very naturally a compilation of analyses. However, so many of the Japanese foods are unfamiliar outside of the East that some description of at least the commoner kinds seems desirable. For the better understanding of the analytical data the descriptive matter precedes the table of composition.

FOOD STAPLES AND WAYS IN WHICH THEY ARE USED.

The three great staple food materials in Japan are rice, barley, and soy beans. The most important of all is rice, though in the poorer country districts it is too expensive for general use, and is replaced entirely or in large part by some cheaper grain, wheat, barley, and especially millet being more common. The peasantry use also considerable amounts of buckwheat, radish, certain varieties of Brassica allied to cabbage, and comparatively small amounts of fruits and nuts. Potatoes are used in the northern islands, and in the southern islands sweet potatoes are a staple food.^a

The chief animal food is fish, which is much used near the seashore and less extensively in the interior. Poultry and eggs are used in small amounts, and beef, mutton, and pork form an inappreciable part of the diet of the people in general. Such animal foods as meat, milk, and butter are used more extensively in the cities, especially by the wealthier classes, than in any other region.^b

In the case of rice, barley, and millet the cleaned grain (i. e., with hulls or chaff removed) is generally used without grinding, though barley and millet are commonly cracked. Buckwheat is generally ground, most of the flour being used to prepare soba (see p. 21). Wheat is ground, and is used to some extent in the manufacture of macaroni, vermicelli, and cakes, but more largely in combination with soy beans in the preparation of shoyu. Legumes are used to some extent in the natural state, but the amount thus used is small compared with that employed in the manufacture of miso, shoyu, and tofu, which are of universal use in Japan. A few sorts of fish are eaten raw. Fish are also cooked, or made into various preparations. In fact very much of the food eaten in Japan consists of prepa-

^a According to statistics collated by the Department of Agriculture and Commerce, Tokyo, for the year 1880, the total vegetable food consumed was made up approximately as follows: Rice, 53; barley and wheat, 27; millets, buckwheat, and legumes, 13.9; tubers and vegetables, 6; fruits, 9.95, and marine algæ 0.05 per cent.

^b According to data in the Yearbook of the Bureau of Statistics, Tokyo, for 1900, the amounts of animal food available per capita for that year were as follows: Meats (weight as purchased), 1.3 pounds; fresh fish, 26.9 pounds; dried fish, 2.5 pounds, and imported meats and fish, 0.3 pound.

rations of different kinds that may be preserved for longer or shorter periods. The more common of these preparations are here described, a concise explanation of the method of preparation being given, and in some cases a brief discussion of the nature of the chemical constituents also.

PREPARATIONS OF FISH.

DRIED BONITO.

The dried flesh of the bonito (*Symnosaida affinis*) is one of the most common food adjuncts in the Japanese dietary. It is used with either miso or shoyu, and such combinations are considered well-nigh indispensable in cooking. The appetizing flavor imparted by the water extract of dried bonito is especially prized.

To prepare the dried product, the fresh bonito meat is well washed and put directly into boiling water and the boiling continued for some time. The flesh is thus made tender without the removal of a large proportion of the extractives. When sufficiently boiled the fish is cooled, the bones are removed, and the edible material dried over a fire for an hour, after which it is kept in a drying room for eleven days or longer. When properly dried it is packed in boxes or wrapped in straw. Usually within a day a growth of fungus will be observed upon the surface. The fish is then removed from the box, cleaned from fungus, and further dried. This process is repeated until no fungus growth appears, at which time the fish flesh is finally boxed for preservation and use.

In preparing the water extract mentioned above, dried bonito is chopped into small fragments, or nearly to powder, and put into water containing miso or shoyu, usually in the proportion of 50 or 60 grams of the fish to a liter of water, and then boiled. Nearly 15 per cent of the dried material of the flesh is extracted. For fine cooking only the aqueous extract is used, the residue being thrown away; but in other cases both the extract and the residue are used together.

The nature of the extractives from dried bonito was studied by Kitao,^a who found the percentage composition of the water-free substance of the extract to be as follows: Total organic matter, 81.34 per cent; protein ($N \times 6.25$), 57.34 per cent; ash, 18.66 per cent. Among the nitrogenous compounds he found no albuminoids,^b i. e., no albu-

^a Cited by Tsuji, Nikushoku Heu, Tokyo, 1894.

^b The use of these terms here and throughout this publication is that approved by the U. S. Association of Agricultural Colleges and Experiment Stations (see Report of Committee on Nomenclature, U. S. Dept. Agr., Office of Experiment Stations Bul. 65, pp. 117-123). The term albuminoids is applied to the albumins and globulins and their derivatives, and with them the so-called compound proteids of which they are constituents. The related compounds, like collagen, chondrin, and gelatin, are designated as gelatinoids. The albuminoids and gelatinoids are classed together as proteids. The collective term protein is used to include the proteids, extractives, amids, etc., which together comprise the nitrogenous constituents (exclusive of nitrogenous fats) of food materials.

mins or globulins, or derivatives from them. Nearly a fifth of the total nitrogenous material was found to be precipitable by tannin, indicating the presence of a large amount of gelatin. Creatin and creatinin were identified. Certain substances with the characteristics of xanthin and hypoxanthin were also found. The ash consisted largely of phosphates. Apparently the bonito extract is similar in composition to beef extract, and probably has a similar function as a food adjunct.

KAMABOKO AND HAMPEN.

These are two of the most common forms of fish preparations in the Japanese markets. In preparing them the skin and bone are carefully removed from the fish, and the flesh is then well ground in a mortar and mixed with wheat flour and a little salt. The mixture is molded into various shapes and cooked by steaming or broiling. It is then ready for the market. These preparations are eaten either in the fresh condition in which they are purchased, or after being further cooked with shoyu in combination with vegetables. In a favorite dish made of white beans, kamaboko is an indispensable ingredient.

PREPARATIONS OF CEREALS.

BREAD.

The making of bread has been introduced in Japan in recent years. Thirty years ago bread was almost unknown there, save to very few people, and its use is still limited and is not increasing very rapidly. In the navy bread is used quite freely, as will be seen in the dietary studies included in the present compilation. In a country where the kitchen utensils and the methods of cooking are so different from those employed in the Occident, and where one can scarcely find a range or kitchen stove, bread making must necessarily be but very slowly adopted.

FU.

This is a gluten preparation obtained from wheat flour. The whole is mixed with water and made into a dough which is kneaded, the kneading and addition of water continuing until the larger part of the starch is removed. What remains is known as "fu," and is used either in the fresh state as an ingredient of soup, or is roasted to preserve it for future use.

MACARONI AND VERMICELLI.

These preparations have long been known in Japan. In a Japanese record of the latter part of the eleventh century, vermicelli is mentioned in such a way as to indicate that it was in general use at the time. In preparing these products wheat flour is kneaded with water

containing some table salt, pressed into a thin layer, cut into narrow strips like noodles, and dried; though for macaroni intended for use in the fresh state no salt is added. Vermicelli is more extensively used than macaroni, and forms one of the delicacies of the Japanese dietary. It is cooked by boiling in water and eaten with a sauce made from shoyu and bonito extract. Macaroni is generally used for soup.

SOBAKIRI.

Sobakiri, or soba, as it is also called, is a buckwheat preparation made in practically the same way as fresh macaroni. It is commonly used in the fresh state, although dried soba is prepared to a limited extent. In preparing for the table it is either steamed or cooked in boiling water and eaten with sauce made of shoyu and bonito extract.

MOCHI.

This preparation, which is sometimes though not properly described as rice bread, is a glutinous rice cake. While the term mochi is generally applied only to the preparation from glutinous rice, it may also be applied to any cake made from glutinous grains, like millets. In the latter case some special prefix denoting the kind of grain used is also employed, as, for instance, Kibi-mochi, or Awa-mochi (Kibi is *Panicum miliaceum*; Awa is *Setaria germanica*). The use of mochi made from glutinous millets is usually confined to the rural and laboring classes.

To prepare the mochi glutinous rice is soaked in water, steamed well, pounded and kneaded into a thin sheet, and then cut into small square or rectangular cakes. The size of the cake varies according to locality, but is usually about 8 by 10 centimeters in breadth and 1 centimeter thick. Mochi is considered one of the essential articles of food for New Year's feasts. It is generally eaten either roasted or cooked with shoyu sauce.

Glutinous rice (*Oryza sativa glutinosa*) is easily distinguished from ordinary rice after the husk is removed; the grain of glutinous rice is translucent, whereas that of ordinary rice is white and opaque. The name glutinous rice is doubtless given because of its peculiar property of forming, when steamed and beaten, pasty lumps of great tenacity, a property which is not shared by ordinary rice. The glutinous rice flour is colored red or red-brown by iodine solution, whereas that of common rice is colored deep blue.

It was naturally suggested that the peculiar property of glutinous rice was due to gluten, as in wheat. However, from a comparative study of the chemical composition of both kinds of rice, Atkinson,^a in an investigation on the chemistry of sake brewing, found no great

^a Mem. Sci. Dept., Tokyo, 1881.

difference between them in respect to the proportions of albuminoids soluble in alcohol, or the quantities of material soluble in cold water. According to him, the differences between the two kinds of rice are due less to the nature of the albuminoids than to the proportion of dextrin present.

According to Dafert,^a the essential difference between the glutinous and ordinary rice is due not so much to the proteids as to the carbohydrates, and more especially to the nature of the granulose in the starch. In ordinary rice the starch cell consists of ordinary granulose inclosed in cellulose, which gives the characteristic blue color with iodine. In glutinous rice the granulose is replaced by erythro-granulose, which gives a red or red-brown color with iodine. Daffert designates this kind of starch as erythro-amylum.

A. Meyer^b takes a different view, namely, that the starch cell of glutinous rice includes a considerable amount of "amylo-dextrin" and dextrin into which forms the starch ("amylose") has been changed by the action of a special ferment during growth. This conclusion is also supported by the work of Shimoyama^c carried on in Meyer's laboratory.

The peculiar nature of the starch of glutinous rice is shared apparently by all glutinous varieties of millets and other cereals.

AME.

This material is prepared most commonly from glutinous rice or glutinous millet, sometimes from common rice, and rarely from Indian corn or from sweet potatoes. The essential feature of the process of ame preparation is the conversion of starch into maltose by diastase. Malt, or sprouted barley, is generally used to furnish the diastatic ferment. The cleaned rice or millet is soaked in water and then steamed, by which process the starch grains are broken open and made easily accessible to the ferment. The steamed grain is then transferred to a suitable vessel, mixed with certain proportions of powdered malt (added fractionally) and of water at about 60° C., and well stirred. The mixture is kept at a temperature of 50° to 60° C. In the course of 6 to 8 hours the diastatic ferment has acted upon the starch and converted it largely into dextrin and maltose. The liquid mass is then filtered by pressing through a fine linen bag, and the filtrate is condensed in a double boiler to the proper consistency, which varies slightly according to the season.

The material thus prepared is called midzu-ame, which means liquid, or soft ame. It is a dense, clear, light amber-colored liquid,

^a Landw. Jahrb., 1885, p. 837; 1886, p. 259.

^b Ber. Deut. Bot. Gesell., 1886, p. 337; 1887, p. 171.

^c Beiträge zur Kenntniss des japanesischen Klebreises. Inaug. Diss., Strassburg, 1886.

not unlike the best commercial glucose in some of its physical properties. It is used in this form, or is further concentrated into kata-ame, or hard ame, a sort of hard, white, sweet candy. Stick ame is also made from midzu-ame by pulling.

Ame has been manufactured in Japan for at least two thousand years, and long before sugar was known it was used for flavoring articles of food. Even at the present time it is sometimes used in place of sugar in cooking. Ame is also a favorite food adjunct for invalids.

An interesting discussion of the relations between midzu-ame as made by the Japanese and malt products of European countries before sugar was so generally known is given by Storer and Rolfe,^a in which the process of ame making is described by Takaki, from information obtained from Japan. In the same publication is given also the translation by Takaki^b of a "Note on ame," published in Japanese by Furukowa.^c A description of the manufacture of midzu-ame from maize has been given by Wiley and McElroy.^d

Whether made from glutinous rice, ordinary rice, millet, or corn, ame consists mainly of maltose and dextrin. Kokashima^e gives the following as the average of three analyses of samples of ame made from glutinous rice: Water, 15 per cent; protein, 1.1 per cent; maltose, 50 per cent; dextrin, 33.6 per cent, and ash, 0.3 per cent. These figures are almost identical with those given by Furukowa.^f The composition of ame from ordinary rice, as given by the latter, is as follows: Water, 17.4 per cent; protein, 0.8 per cent; ether extract, 0.1 per cent; maltose, 58.1 per cent; dextrin, 23.3 per cent, and ash, 0.3 per cent.

Furukowa states that "since the rice ame is rich in maltose and poor in dextrin, it has a sweeter flavor than the glutinous rice ame, the flavor of which is weaker in consonance with a similar quantity of maltose and a larger amount of dextrin in it. Since the proportion of nitrogenous matter in both kinds of ame is minute, this constituent would not readily suffer decomposition even if the ame were to be kept for a long time."

THE SOY BEAN AND ITS PREPARATIONS.

Next to rice in importance in the Japanese diet are the legumes, which are universally used. They are of particular value in the diet, because being rich in protein they serve to increase the supply of this

^a Bul. Bussey Inst., 3 (1904), p. 80.

^b Loc. cit., p. 95.

^c Tokyo Iji Shinshi (New Med. Jour. Tokyo), 1885, No. 365, p. 355.

^d Agr. Sci., 6 (1892), p. 57.

^e Nippon Shokushi, Tokyo, 1885, p. 233.

^f Loc. cit.

necessary nutrient, in which cereals, especially rice, are relatively very deficient. Of the different legumes used as food in Japan, the soy bean^a (*Glycine hispida*) is by far the most important. According to agricultural statistics for the years 1879 to 1887, nearly 10 per cent of the total cultivated land in Japan was devoted to the growth of this legume, an area somewhat larger than that devoted to wheat growing. In the northern island in 1887 nearly 17 per cent of the total cultivated area was devoted to the soy bean. The average yearly production of soy beans amounts to about 360,000,000 kilograms, according to the statistics mentioned above. A part of the product is of course used for seed, and a not inconsiderable part is used as fertilizer.^b

Other legumes besides the soy bean, such as peas (*Pisum sativum*), mungo bean (*Phaseolus mungo radiatus*), or adzuki bean (*Phaseolus mungo subtrilobata*), are also used to a considerable extent, but the quantity of these produced in Japan is not accurately known. It has been estimated, however, that the quantity of such legumes imported annually is equal to nearly one-eighth of the total amount of soy beans produced in Japan. Fesca,^c who has given much attention to the study of agricultural production in Japan, has estimated that the quantity of both imported and domestic legumes other than soy beans will equal the amount of the latter used for seed, for fertilizer, etc., so that the total production of soy beans may be taken as a measure of the total quantity of legumes consumed for food.

Many varieties of soy beans are known, being designated according to the color, size, or shape of the seed, and the time required for maturity. For example, there are black, green, yellow, and white varieties, and these are again designated as early, medium, or late, according to the season of maturity, and small, medium, and large, according to the size of the seed. The black soy beans are used chiefly for cooking, with sugar and shoyu; the green variety is also used in this way, either in the fresh state or after being dried. But the total quantity of soy beans used in Japan simply for cooking in the natural state is relatively small, the chief use being for the different leguminous preparations, the principal of which are tofu, miso, and shoyu, described beyond. For the preparation of these products either white or yellow soy beans are used, preference being given, however, to certain special varieties for each of these preparations.

^a In this publication we have followed popular western usage in applying the name soy bean to all varieties of *G. hispida*. In Japan, however, the term shoyu, from which "soy" has doubtless been derived, is applied only to particular varieties of the beans. (See p. 30.)

^b In northern China soy beans are used to some extent in the production of oil, which is used for cooking and for illumination. The residue from this process is imported largely into Japan, where it is used as a fertilizer.

^c Beiträge zur Kenntniss der japanesischen Landwirtschaft, Vol. II, p. 265.

The chemical nature of the different constituents of the soy bean has been studied by a number of investigators; attention is here given more particularly to the nitrogenous materials, which are of first importance.

Meissl and Böcker,^a who studied the chemical constituents of the soy bean extensively, found as the chief nitrogenous body "casein," resembling legumin in other leguminous seeds. They also obtained a small quantity of albumin which differs from common albumin in its chemical composition and properties, and which very closely resembles the albumin obtained from peas. According to these investigators the soy bean contains about 30 per cent soluble casein, 7 per cent insoluble casein, 0.5 per cent albumin, and a very small amount of amid bodies.

More recently Osborne and Campbell^b made a thorough investigation of the proteids of the soy bean. They examined two varieties, one known as yellow soy bean and the other a variety which in Japan is called Kyusuke soy bean, and is popularly used in the manufacture of tofu, miso, and shoyu. According to these investigators the chief proteid constituent of the soy bean is glycinin, a globulin similar to legumin in properties but differing from it somewhat in composition, containing nearly twice as much sulphur, 0.4 per cent more carbon, and 0.5 per cent less nitrogen. The soy bean contains also a small amount of a more soluble globulin which resembles phaseolin in composition and in its reactions. Besides this globulin about 1.5 per cent of the albumin-like proteid legumelin was obtained. A small amount of proteose was also present.

According to the studies of Nishimura^c and Blasdale,^d from 91.5 to 98.7 per cent (94.5 in the average of four analyses) of the protein of soy bean exists in the form of albuminoids.

Concerning the chemical character of the fat of soy bean comparatively little has been ascertained. Meissl and Böcker^e found that the ether extract consists of 40 to 95 per cent of neutral fat and 5 to 10 per cent of cholestrin, lecithin, wax, and resins. The fat has a characteristic leguminous taste. When kept for two years it became thick, but was only slightly rancid. Its specific gravity was 0.89 at 15° C. One gram of soy-bean fat required 191.8 milligrams potassium hydroxid for saponification. The fat has also been examined by Stingl and Morawski^f and by Roelofsen^g with reference to

^a Sitzber. K. Akad. Wiss. [Vienna], Math. Naturw. Kl., 87 (1883), pt. 1, p. 371. Centbl. Agr. Chem., 13 (1884), p. 52.

^b Jour. Amer. Chem. Soc., 20 (1898), p. 419.

^c Miso Shoyu Jozohen, Tokyo, 1896, p. 18.

^d U. S. Dept. Agr., Office of Experiment Stations Bul. 68, p. 33.

^e Loc. cit.

^f Chem. Ztg., 10 (1886), p. 140.

^g Amer. Chem. Jour., 16 (1894), p. 467.

its iodine absorption. The figures obtained for the latter constant were 121.3 and 138.8, respectively, and these and other facts indicate that the oil has poor drying properties.

The chief carbohydrate constituent of soy bean is galactan, as was first suggested by the work of Levallois,^a who noted 9 to 11 per cent of material soluble in alcohol which did not reduce Fehling's solution. The galactan was later fully identified by Maxwell.^b He also identified paragalactan, an insoluble carbohydrate.

There has been a considerable difference of opinion among investigators regarding the presence of starch in soy beans, some European investigators reporting from 3 to 5 per cent, while Japanese investigators have not identified starch in the native soy bean. The weight of evidence, however, indicates that under certain conditions starch in considerable amounts may be present. In 1880 Meissl and Böcker^c made an extended study of soy beans and reported starch, the amount found being less than 3 per cent. The starch grains are described as being extremely small and different in form from the typical bean or pea starch. About the same time Hanausek^d also reported starch in soy beans. It was found deposited where the surface of the cotyledons meet. The grains were embedded in fat and so gave no color reaction after a prolonged treatment with iodine. A more extended study of soy beans was reported by Harz.^e He found that when the beans do not ripen thoroughly or when allowed to ripen after the vines are cut starch may be present, some varieties being more likely to contain it than others. If the beans are thoroughly ripened they are practically starch free.

The presence in soy beans of a small quantity of dextrin is reported by Stingl and Morawski,^f as well as about 2 per cent of a mixture of different sugars which could be readily fermented. The investigators, however, were principally concerned with the diastatic ferment found in the beans, and a number of tests regarding its amount are reported.

TOFU.

This term is commonly translated as bean cheese—though sometimes as bean curd—in English and Bohnen-käse in German. Tofu is not strictly equivalent to cheese, however, as neither bacteria nor ferments are involved in the process of manufacture. It consists

^a Compt. Rend. Acad. Sci. [Paris], 93 (1881), p. 281.

^b Amer. Chem. Jour., 12 (1890), p. 51.

^c Sitzber. K. Akad. Wiss. [Vienna], Math. Naturw. Kl., 87 (1883), pt. 1, p. 372.

^d Ztschr. Allg. Österr. Apoth. Ver., 22 (1884), p. 474.

^e Ztschr. Allg. Österr. Apoth. Ver., 23 (1885), p. 40; Landwirtschaftliche Samenkunde. Berlin: P. Parey, 1885, p. 692.

^f Monatsh. Chem., 7 (1886), p. 176.

chiefly of the albuminoid materials of the soy bean combined with magnesium and calcium salts, as pointed out by Inouye.^a

The method of preparation is in brief as follows: The soy beans are soaked in water for about 12 hours and then crushed between millstones until of a uniform consistency. The mass is then mixed with about three times its bulk of water and boiled for about an hour, after which it is filtered through a cloth. By this process nearly 30 per cent of the total protein of the beans is dissolved and contained in the filtrate, ready to be precipitated as tofu. The filtrate is white and opaque, somewhat resembling milk. To this is added, with constant stirring, about 2 per cent of the concentrated mother liquid obtained in the manufacture of salt from sea water, whereupon the albuminoid material is precipitated in combination with calcium and magnesium salts. The liquid is filtered off, and the precipitate, which is tofu, is pressed in a wooden frame and then cut into cakes usually about 10 centimeters broad, 2 centimeters thick, and 25 centimeters long, though the size varies in different localities.

The residue from the boiled and filtered beans is known as kara, or tofu cake, and contains a large quantity of protein and carbohydrates. It is a good food material, being used considerably by poor people as an ingredient of miso soup.

If the milky filtrate mentioned above is boiled, a sort of film forms on the surface. This film, which consists mainly of coagulated albuminoids and fat, is sometimes prepared in large quantity, and when dried is used as an article of food, being known as yuba.

Tofu is generally prepared every day, and is eaten in the fresh condition simply with a little shoyu, though it is also frequently cooked in shoyu or in miso soup. Fried tofu, called abura-age, is also a very popular article of food. Rape-seed oil is generally used in frying, though sesame-seed oil is sometimes used.

Tofu may also be prepared for preservation and transportation. For this purpose it is cut into smaller pieces and exposed to severe cold weather, to remove the water by freezing, and then dried in an oven. As thus prepared it can be preserved for several years. When the tofu is frozen the water collects in fine needles of ice distributed throughout the mass. When the ice melts and the water runs out, it leaves the tofu porous and it may be easily dried. If it is not frozen, it is difficult to dry it and the resulting material is dense and horn like.

^a Bul. Col. Agr., Tokyo Imp. Univ., 2 (1895), No. 4, p. 209.

The average composition of the above-mentioned tofu preparations is shown in the following table:

TABLE 2.—*Composition of tofu preparations.*

	Water.	Protein.	Fat.	Carbo- hydrates.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per ct.</i>
Fresh tofu.....	88.11	6.29	3.38	1.64	0.58
Frozen tofu.....	18.72	48.65	28.65	2.33	1.65
Fried tofu.....	57.40	21.96	18.72	.57	1.35
Tofu cake.....	84.49	5.23	1.58	8.04	.66
Yuba.....	18.31	49.65	18.00	11.82	2.22

As would be expected from the above explanation of the process of manufacture, the proportion of protein to carbohydrates is relatively large in all the preparations except the tofu cake, the carbohydrates of the beans being left behind in the residue of which the latter is composed.

The digestibility of the nutrients in tofu has been found to be high, as will be seen from the results of digestion experiments summarized later (p. 191). As much as 95 per cent of the protein is digested and about the same proportion of fat. The carbohydrates were found to be somewhat less digestible when the tofu was eaten alone, but when it was eaten with rice about 99 per cent of the total carbohydrates of the diet was digested.

Both the composition and the digestibility of tofu, therefore, prove it to be a very nutritious food material. This is extremely significant, because tofu in its various forms is used very extensively by all classes of Japanese. In the interior of the country, where fish can not be easily obtained, it is a most important source of protein. For the Buddhist priests, as well as the strict adherents to Buddhism (who eat no animal food), it forms a very popular and almost indispensable dietary article. Though no authentic record has been found regarding the origin of the manufacture of tofu in Japan, it is believed on good authority that the method was first introduced from China by Buddhists for their own use.

MISO.

This material is prepared from a mixture of soy beans, barley, common salt, and water by a slow process of fermentation. Although it is highly probable that the process of preparing miso was first introduced either from China or from Korea, the exact date of the introduction is not known. Mention is made of miso in a Japanese record of the latter part of the ninth century.

In the extent to which it is used miso surpasses all other preparations from soy bean. Among the rural population and wage-earners in general it forms an indispensable part of the daily menu; among

the people living in cities, however, it is used somewhat less extensively. Its chief use is in making soup and in cooking vegetables. For this latter purpose, however, miso and shoyu are to a certain extent replaceable, and generally where more shoyu is used the amount of miso consumed is smaller.

Since it is the general custom of the people in rural districts to prepare miso for their own use, no accurate statistics regarding the total quantity manufactured and consumed are available. It has been estimated that the daily consumption of miso per person in the rural districts is about 40 grams. In the statistics of 25 dietary studies described beyond (p. 131), with people living elsewhere than in the country, the average daily amount was 43 grams, but the range was from 13 to 100 grams.

The production of miso depends primarily upon the action of a fermenting agent known as koji. The process of preparing the koji used for miso is similar to that for sake-koji (see p. 36), except that for the latter only rice is used, whereas miso-koji may be made from either rice or barley. The object of preparing miso-koji is to propagate certain forms of fungi, of which *Aspergillus oryzae* is the principal one. The koji also contains diastatic and inverting ferments which change the carbohydrates of the raw materials into maltose, glucose, etc., and a proteolytic ferment which acts upon the nitrogenous bodies, converting them into simpler and more soluble materials. The yeast which causes alcoholic fermentation is also regularly present. Koji is dried and finely powdered before it is used.

To prepare miso the soy beans must first be steamed, and upon this process depends largely the quality and especially the color of the final product. The steaming is continued usually twenty-five hours, at first with strong heat but later very gently. When the beans are properly steamed and cooked, they are rubbed into a thick, uniform paste, to which are added proper amounts of powdered koji, salt, and water. The whole mass is then well mixed and stored in a special vat. The temperature of the mixture is kept at about 15° to 20° C., though as the fermentation advances it rises often to 25° C.

Different kinds of miso are distinguished by color, taste, and keeping properties, and are prepared by somewhat different processes, the differences consisting chiefly in the use of rice or barley koji, the amount of common salt added, a longer or shorter fermentation, and the temperature at which it takes place. Two of the most important kinds of miso are the following:

White miso.—This material is white in color, contains a small amount of common salt, is fermented with rice-koji for three to four days, and may be preserved about ten days.

Red or sendai miso.—This material is red in color, contains a relatively large amount of common salt, is fermented usually with barley-koji for one and one-half to two years, and may be preserved for several years.

The following figures, taken from the results of investigations by Kellner and his associates,^a show the composition of these two kinds of miso:

TABLE 3.—Composition of white and red miso.

	Water.	Dry matter.	Material soluble in cold water.	Protein.	Fat.	Fiber.	Starch, dextrin, etc.	Glucose.	Alcohol.	Common salt.	Total ash.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
White miso..	59.27	39.78	22.13	10.18	5.10	1.99	6.31	8.32	0.95	5.99	7.78
Red miso....	50.16	48.66	32.28	12.48	6.46	2.31	2.72	10.40	1.18	10.84	12.48

In the white miso 27.5 per cent and in the red miso 33 per cent of the total nitrogen was present in nonproteid form. In both cases a small amount of ammonia was found and also the following amounts of acid: In white miso 0.05 per cent volatile acid (as acetic) and 0.16 per cent nonvolatile acid (as lactic); in red miso 0.02 per cent volatile acid (as acetic) and 0.14 per cent nonvolatile acid (as lactic).

Miso is characterized chiefly by the solubility of its constituents in water, owing largely to the vigorous action of the proteolytic and diastatic ferments of the koji used. The presence of an appreciable amount of alcohol is also noticeable.

SHOYU.

Shoyu, or "soy sauce," is a dark-brown, moderately thick liquid very popular for use in cooking, and as a relish or condiment to increase the flavor and palatability of the diet. In odor and taste it is not unlike a good quality of beef extract. It is prepared from a mixture of soy beans, wheat (or sometimes barley), salt, and water by long-continued fermentation. For the preparation of shoyu a large and late variety of soy bean, that is rich in protein, is usually recommended. The varieties especially adapted to this purpose are called shoyu beans. The western name "soy bean" for all varieties of *Glycine hispida* very probably owes its origin to this fact.

As shown by the average for five years (1887–1891), the annual production of shoyu in Japan, so far as statistics could be obtained, amounted to 221,000,000 liters. A small portion of the total product is exported, but this is more than counterbalanced by what is manufactured privately in rural districts and not included in the statistics quoted. It may be inferred from these figures that the yearly

^a Bul. Col. Agr., Tokyo Imp. Univ., 1 (1889), No. 6.

consumption per capita amounts to not less than 5 liters. It is generally estimated, however, on good authority, that the annual consumption per adult is 9 to 10 liters. In the average of 28 dietary studies included in the present compilation, 36 grams of shoyu were used per man per day, an amount equivalent to nearly 11 liters per annum, which is in agreement with the higher estimate quoted above.

The term "hishiwo," which is considered as applying to a crude form of shoyu made without filtering, is found in a Japanese record dating from the early part of the eighth century. The manufacture of shoyu in its present form originated much later, probably in the sixteenth century, and has been gradually brought to the improved form of the present day.

In the preparation of shoyu, nearly equal parts of beans, wheat, and salt, and double the quantity of water are used. The wheat is roasted and pulverized. The beans are steamed and mashed in the same manner as in the preparation of miso, and when cooled to about 40° C. the powdered wheat is added (in the proportion of 70 parts of the cooked beans to 30 parts of the wheat by weight) and the mass thoroughly mixed. Spores of *Aspergillus oryzae* are then added and the mass is again thoroughly mixed and spread upon wooden vessels or trays, about 3 liters on a tray, and the trays are stacked away, one above another, in a cellar, the temperature of which is kept somewhat above 4° C. After 20 to 25 hours the mycelium of the fungus will be found. With the growth of the fungus there is an energetic evolution of heat and carbon dioxide. Ventilation and cooling are now necessary, and are effected by opening the windows of the cellar and by mixing the material on the trays by hand. The temperature of the mixture is thus kept not far from 27° to 28° C. In about six days the growth of the fungus is completed and an abundance of yellowish spores is present. The material is then dried and ground.

The product at this stage corresponds to the koji prepared in the manufacture of miso, described above, the ferments present being the same as those in the miso-koji. The difference in the two processes is that in the manufacture of miso only barley (or rice) is made into koji, whereas in the case of shoyu both the beans and the wheat are converted into koji.

To the shoyu-koji thus prepared and pulverized are added water and salt, the salt being first dissolved in water in the proportion mentioned above, and the solution heated to 115° to 118° C. When the saline solution is cooled to the temperature of the air, the koji is added and the mixture well stirred. This material is kept in casks and allowed to ferment. It is stirred from time to time, the stirring being at more frequent intervals as the process of fermentation advances. The fermentation is allowed to continue usually one to

two years, though often as long as five years. It is believed that the longer the period of fermentation the better the quality of the product, other things being equal. When the fermentation is completed, the mass is filtered and pressed and the filtrate is allowed to settle two to three days. The clear supernatant liquid is then removed and heated to 70° to 100° C. in a double boiler for 2 to 3 hours, after which it may be kept for a long time. To improve the taste, it is usual to add a certain quantity of sugar or sweet sake during the heating process.

The general composition of shoyu is illustrated by the following table showing data for three different samples:

TABLE 4.—Percentage composition of shoyu.

Sample number.	Specific gravity.	Water.	Protein.	Carbohydrates.		Free acid (as lactic).	Ash.	Common salt.	Phosphoric acid.
				Glucose.	Dextrin.				
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....	1.185	62.39	9.28	2.70	0.69	1.18	18.48	16.03	0.53
2.....	1.190	62.82	9.53	3.33	.69	1.33	18.70	15.67	.51
3.....	1.208	60.58	9.15	5.85	1.43	.92	20.14	17.47	.46

The chief chemical changes involved in the manufacture of shoyu are those resulting from the action of the proteolytic and diastatic ferments, and to some extent from the alcoholic ferments.

By the proteolytic ferments part of the proteid material of the soy beans, which comprises at least 98 per cent of the total protein, is converted into forms more soluble than those originally present, and some of it is still further broken down into cleavage products such as leucin, tyrosin, etc., and even into ammonia. Nagai and Murai^a found in a sample of shoyu that contained 0.74 per cent total nitrogen (equivalent to 4.63 per cent protein) 0.68 per cent soluble albumins and 1.79 per cent peptone. Tahara and Kitao^b also studied the different forms of nitrogen existing in shoyu. Of the 1.18 per cent of total nitrogen present, 55 per cent was found to be in the form of proteid nitrogen. Among nonproteid substances they found 0.46 per cent leucin and 0.21 per cent ammonia.

The chief effect of the diastatic fermentation is the production of glucose. The effect of alcoholic fermentation is more noticeable in the earlier stages of manufacture, the amount of alcohol being larger then than later in the fermentation period. Tahara and Kitao found 0.43 per cent of alcohol in their sample. The decrease in the quantity of alcohol as fermentation advances is probably due to further decomposition of alcohol into acid and the subsequent formation of esters, which produce agreeable flavors.

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1897, No. 8, p. 35.

^b Tokyo Yokugaku-Zasshi (Jour. Tokyo Pharm. Soc.), 1887, No. 61.

These various forms of fermentation, especially the proteolytic fermentation, are of particular importance in the manufacture of both miso and shoyu. The proteids and carbohydrates present have a high food value. The cleavage products have little or no direct food value, but they are useful in imparting flavor and in stimulating the appetite and the digestive functions. Miso and shoyu, then, combine the properties of both food and food adjuncts. They are decidedly valuable as food because of the proteids and the carbohydrates which they contain, and their value is undoubtedly increased by their peculiar and appetizing flavor, which imparts a relish to other foods with which they are used. Although there is no direct food value in flavor, it is of considerable importance in the diet because of its aid in stimulating the appetite. Some food constituents, notably some of those with distinct flavors, have also been found to directly stimulate the digestive functions, as shown in the recent work of Pawlow and his associates.^a The vegetable diet of the Japanese people at large is more or less monotonous, hence the value of these preparations. Indeed, the variety which they afford as food adjuncts can hardly be overestimated.

NATTO.

Natto has long been used by the Buddhists. It is prepared by boiling the soy beans in water for about five hours to render them very soft; the hot material is then wrapped in small portions in straw, and the bundles, tied at both ends, are placed in a cellar in which a fire has been kindled. The cellar is then closed for twenty-four hours and the cooked beans allowed to ferment in the warm, moist atmosphere. The fermented product is a thick viscid mass having a peculiar but not offensive odor. Four different micro-organisms,^b the source of which is supposed to be either the straw or the air of the cellar, participate in the fermentation. The principal chemical change concerned in the ripening of natto takes place in the protein.

In the water-free substance of natto, Yabe^c found the following percentages of nitrogen in different forms: Albuminoid nitrogen 4.03, peptone nitrogen 1.62, and amid nitrogen 1.89 per cent.

The cleavage products leucin, tyrosin, and xanthin were also identified.

^a The Work of the Digestive Glands. London, 1902.

^b Yabe found 1 bacillus and 3 micrococci.

^c Bul. Col. Agr., Tokyo Imp. Univ., 2 (1894), No. 2.

MISCELLANEOUS FOOD PRODUCTS.

DRIED ALGÆ.

Several different species of marine algæ are used as food in Japan. All of those most commonly used are included in the table of composition of Japanese food materials on page 40. Although the algæ have some food value, they are prized chiefly for their flavor. Their actual value doubtless depends in considerable measure upon the mineral salts they contain. Laminaria is probably the most popular and most extensively used, several species being known in Japan. It is generally cooked in combination with dried beans or dried fish. As an ingredient of soup the mucilaginous extract of the plant (which contains mineral matter in addition to carbohydrates) is chiefly valued, the insoluble residue being thrown away. Two species, *Enteromorpha linza* and *Porphyra laciniata*, are prepared in a special way for market, commonly in thin sheets, and are known under the general name "nori." Immediately before use they are dried over a fire and then broken into small fragments and eaten, usually with other prepared foods. Their flavor is especially prized. The other species of algæ used as food are either cooked with shoyu or used as ingredients of miso soup.

The chemical nature of the constituents of algæ has received but little attention. Several investigators have studied the carbohydrates, especially the mucilaginous matter of Laminaria, but the results obtained are as yet unsatisfactory. Mannit is present in Laminaria, but the amount varies greatly in different species; neither starch nor glycogen was found in studies undertaken by the author.^a *Ulopteryx pinnatifida*^b also contains mannit. The carbohydrates of *Porphyra laciniata* were studied recently by the author with Tollens,^c and found to consist largely of substances which on hydrolysis with acid yielded *i*-galactose and *d*-mannose. There were also found in smaller quantities substances which on hydrolysis yielded glucose, ketose, pentose, and methylpentose (very probably fucose).

BAMBOO SHOOTS.

Young bamboo shoots cooked with shoyu are eaten somewhat, and take the place of asparagus in the European and American diet. Lately asparagus has been cultivated, but only to a very limited extent.

According to Kozai,^d nearly 70 per cent of the total nitrogenous matter in bamboo shoot is in amid form. Tyrosin, guanin, and hypoxanthin were found among the nonproteid compounds present.

^a Report of investigations on marine products, 1902, No. 3, Hokkaido Government.

^b Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1886, No. 1.

^c Ber. Deut. Chem. Gesell., 34 (1901), p. 1422.

^d Bul. Col. Agr., Tokyo Imp. Univ., 1 (1890), No. 7.

KAMPYO.

This is made of a kind of gourd, *Lagenaria vulgaris*. The skin and seeds are removed and the edible portion is cut into long, thin strips and dried in the sun. It is cooked with shoyu and is used quite generally as an ingredient of sushi—that is, boiled rice seasoned with vinegar and salt and rolled in nori.

KONNYAKU.

This is prepared from the tuber of *Hydrosme rivieri* (*Conophallus konjak*). The tubers, from which the skin is removed, are powdered, cooked in water to a soft consistency, and passed through bamboo sieves into a large wooden tub, the residue in the sieve being discarded. To the cooked mass an equal amount of lime is added and 20 parts water. The mass is then well mixed and kneaded, usually with the feet, which are of course previously carefully cleaned. When thoroughly kneaded it is boiled, with the addition of more limewater, to a gelatinous mass, and when cooled it is cut into small rectangular cakes and is then ready for use. It is cooked usually with shoyu and is eaten very commonly.

The tuber of *Hydrosme rivieri* contains no starch, its principal carbohydrates, according to Tsuji,^a being mannan. This is probably the only instance in which mannan is used as a human food to any large extent.

ONIONS.

Several species of the *Allium* group are used as food in Japan. One is *Allium fistulosum*, which in form is more like the leek than the common onion. *A. cepa*, so common in the United States and Europe, has lately been introduced in Japan and is gradually coming into use; but the kind most commonly used and the one to which the name onion is generally applied is *A. fistulosum*, mentioned above. *A. bakeri* is used chiefly in the form of pickles, usually prepared with vinegar, salt, and sugar, though in some instances the salt is replaced by shoyu.

RADISHES.

This term is here applied to *Rhaphanus sativus*, which is much used in Japan. It grows to a large size, frequently 50 to 60 centimeters long and 15 centimeters in diameter. It is used in the fresh state or dried, but is chiefly employed for making "takuwan," which consists of partially dried radish pickled with rice bran. The name is believed to have been derived from a Buddhist, Takuwan, who first suggested the process. This is the most common form of pickle used in Japan.

^a Bul. Col. Agr., Tokyo Imp. Univ., 2 (1894), No. 2.

ALCOHOLIC BEVERAGES.

The principal alcoholic beverage in Japan is sake,^a which is produced from fermented rice without distillation. A distilled liquor called shochu is also made from rice (the residue from sake-making being sometimes used) and other grains, and from potatoes and sweet potatoes, but the total production is small. A small quantity of native wine is made from grapes and in later years there has been some importation of wine from other countries. The making of beer is a new industry in Japan, but is increasing quite rapidly. German methods are followed in brewing, and the products closely resemble German beers.

Sake resembles such liquors as whisky and gin in that it is made from fermented grain, but, unlike these products, is not distilled. In the latter respect it resembles wine, and though wine is a term commonly limited to grape or other fruit products, sake is sometimes called "rice wine" in English.

Sake is a clear liquid, slightly yellow in color, and has a specific gravity of 0.99. It contains 12 to 15 per cent alcohol and 2.5 to 3 per cent extracts, including dextrin, maltose, glucose, glycerin, etc. A small amount of fusel oil is generally present.

The taste of sake has been compared to that of weak sherry that has been kept in a beer bottle. Sake is always heated before drinking, and when used with meals, more usually dinner, it is taken at the beginning of the meal.

The residue of pressed fermented mash from sake making, or sake cake, still contains a large amount of starch and 5 to 6 per cent alcohol. It is used mainly for the preparation of either the distilled liquor called shochu, or for vinegar making. Shochu contains 20 to 50 per cent of alcohol and is used only among the laboring classes. The vinegar commonly used in Japan is prepared either from sake cake or from spoiled sake.

COMPOSITION OF JAPANESE FOOD MATERIALS.

Information regarding the chemical composition of Japanese food materials has been obtained from special studies of the subject and from the results of analyses made in connection with dietary studies, digestion experiments, etc. Data from all these sources are compiled in Tables 5 and 6. It is not claimed that these tables contain all the material of this sort available at the time the compilation was made, the object having been rather to include chiefly that of importance in the investigations described on later pages; but it is believed that

^a The annual production of sake in the year 1897-98 amounted to 840 million liters, or about 19.5 liters per capita; and the Government revenue tax for the year was more than 14 million dollars.

the compilation is, nevertheless, reasonably complete. At least the analyses included in both tables are sufficient to show the general composition of the food materials in most common use in Japan.

As previously stated (p. 12), the first extensive study of the chemical composition of Japanese food materials was made by Tahara, and reported in 1887.^a Table 5 is a translation of the entire table in Tahara's report; it includes also a few analyses of beef, pork, chicken, and eggs taken from König's compilation.^b This table has been used quite extensively by investigators of nutrition in Japan, as a source of data for computing the quantities of nutrients in food used in the dietary studies, etc., compiled in succeeding sections of this publication. In some instances the authors referred to the specific analyses which they used; these are indicated by the numerals 1 to 13 in the column "Reference number" in the table, the numerals being the same as given in a corresponding column in the tables on later pages containing the data of the investigations in which the analyses were used. In the majority of cases, however, the investigators simply referred to Tahara's table without specifying the particular data used. The data which the compiler assumes to have been used, according to the results of the investigations, are indicated by the letter "a" in the column of reference numbers.

Table 6 contains the data regarding analyses made in connection with the dietary studies, etc., on later pages. The majority of the samples were of single food materials, some cooked and some uncooked; but several analyses of composite samples of food are also included. In a considerable number of cases only partial analyses were made, and such other percentages as were used by the investigators were assumed from available data. The values thus assumed are inclosed in parentheses. In a few instances in which the analyses were otherwise complete the percentage of water was not reported.

ENGLISH EQUIVALENTS OF JAPANESE NAMES.

The compiler made special effort to give in both tables English equivalents of Japanese names as accurately as possible; where no common equivalent could be found the scientific name was used. This is especially the case with fishes. For identification of the fishes the compiler is indebted to Dr. S. Nogawa, marine zoologist to the Hokkaido Government, for information given by personal correspondence, and to Dr. K. Fujita,^c whose work on Japanese marine zoology was freely consulted. For the botanical nomenclature we have followed the latest work of Prof. J. Matsumura on Japanese plants.^d

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1887, No. 2.

^b Chemie der menschlichen Nahrungs- und Genussmittel (edition not stated).

^c Nippon Suisan Dobtsugaku, Tokyo, 1902.

^d Shokubutsu Mei-i (Scientific Names of Native and Foreign Plants), 5th edition, 1902.

METHODS OF ANALYSIS.

The methods of analysis followed by different investigators were essentially the same as those in common use in Europe and America.

Water was determined by heating the finely ground substance at 100° to 110° C. in either an air or water bath until the weight was constant.

Nitrogen was determined by the Will-Varrentrapp method (soda-lime method) in the earlier analyses by Osawa, Tahara, and his associates, but later the Kjeldahl method was most commonly followed. Wherever protein was computed from nitrogen the factor 6.25 was always used, but protein in fish was estimated by difference by Tahara and his associates.

The material designated as fat is ether extract, and of course includes, besides fats and oils, other substances which are soluble in ether.

In earlier investigations by Osawa, and by Tahara and his associates, fiber was determined by treating the substance, which was previously freed from fats, starches, etc., with a mixture of nitric acid and potassium chlorate (F. Schulze's method). The weight of ash in the residue from this treatment was determined and deducted. In later investigations the Henneberg and Stohmann (Weende) method was adopted.

Ash was determined by igniting the substance in a platinum dish. If a white ash could not be obtained by ignition, the soluble portion was extracted with hot water and the residue was collected on a filter, burned, and added to the material that remained after evaporation of the aqueous extract, and the whole was again ignited at a low heat until the ash was white.

Nitrogen-free extract was usually determined by difference, although in some instances direct determination after hydrolysis was made by Allihn's method.

TABLE 5.—Percentage composition of Japanese food materials analyzed by Tahara and associates.

Reference No.	Food materials.	Water.	Protein.	Fat.	Carbohydrates.		Ash.
					Nitrogen-free extract.	Crude fiber.	
	<i>Animal food.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per cent.</i>		<i>Per ct.</i>
a	Beef, medium fat ^a	72.25	21.39	5.19	.....		1.17
a	Beef, average ^a	70.96	19.86	7.70	0.41		1.07
	Pork, fat ^a	47.40	14.54	37.34			.72
	Pork, lean ^a	72.18	19.91	6.81			1.10
	Horse meat ^a	73.62	24.49	.72			1.17
a	Chicken meat, fat ^a	70.06	18.49	9.34	1.20		.91
a	Chicken meat, lean ^a	76.22	19.72	1.42	1.27		1.37
1	Eggs ^a	73.67	12.55	12.11	.55		1.12
a	Milk, average 109.....	86.44	3.66	3.99	5.18		.73
a	Milk, condensed.....	31.33	8.39	9.46	48.94		1.88

^a Quoted from König's "Chemie der menschlichen Nahrungs- und Genussmittel."

TABLE 5.—Percentage composition of Japanese food materials analyzed by Tahara and associates—Continued.

Reference No.	Food materials.	Water.	Protein.	Fat.	Carbohydrates.		Ash.
					Nitrogen-free extract.	Crude fiber.	
	<i>Animal food—Continued.</i>						
	<i>Fish:</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per cent.</i>		<i>Per ct.</i>
	<i>Acanthogobius flavimanus</i> (goby).....	79.13	18.35	0.50			2.02
a	<i>Ammastrephus pacificus</i> (calamary).....	78.91	19.12	.56			1.41
a	<i>Ammastrephus pacificus</i> , dried.....	21.08	69.53	3.22			6.17
	<i>Achelognathus</i> sp.....	79.00	18.55	1.18			1.27
a	<i>Anguilla japonica</i> (eel).....	69.24	18.09	11.53			1.14
a	<i>Carassius amatus</i> (Crucian carp).....	79.46	17.86	1.45			1.23
a	<i>Clupea pallasi</i> (herring), dried.....	10.85	68.44	13.86			6.85
a	<i>Clupanodon melanosticta</i> (sardine).....	70.25	21.39	6.72			1.64
	<i>Cheilodichthys kumu</i> (guarnard).....	77.38	18.12	3.30			1.20
	<i>Corvula schlegelii</i>	83.07	13.24	2.83			.86
	<i>Cyprinus carpio</i> (carp).....	78.86	18.94	.83			1.37
	<i>Hezagrinus otaki</i> (rock trout).....	76.95	21.03	.45			1.57
	<i>Helicolenus marmoratus</i>	78.38	20.07	.41			1.14
a	<i>Hyporhamphus sajori</i>	56.85	39.18	1.60			2.37
	<i>Konosirus punctatus</i>	73.34	20.43	4.78			1.45
	<i>Lateolabrax japonicus</i>	77.70	18.62	2.59			1.09
2	<i>Limanda yokohamae</i> (dab).....	75.88	21.93	.74			1.45
a	<i>Lophiomus setigerus</i> (angel fish).....	85.86	13.07	.12			.95
a	<i>Leucopageia petersi</i> , dried.....	44.51	49.62	2.07			3.80
a	<i>Misgurnus anguillicandatus</i> (loach).....	77.32	18.43	2.69			1.56
	<i>Octopus octopodia</i> (poulpe), dried.....	18.83	73.14	1.28			6.75
3	<i>Oncorhynchus tshawytscha</i> (salmon), salted.....	61.56	26.10	3.14			9.20
	<i>Palinurus japonicus</i> (spiny lobster).....	76.29	21.52	.42			1.77
a	<i>Paralichthys olivaceus</i> (halibut).....	79.25	19.16	.47			1.12
a	<i>Parastipoma japonicum</i>	78.24	19.62	.80			1.34
4	<i>Pagrus major</i> (porgy), lean.....	77.61	20.28	.75			1.36
5	<i>Pagrus major</i> (porgy), fat.....	77.90	17.65	3.07			1.38
	<i>Penaeus japonicus</i>	78.49	18.98	1.02			1.51
	<i>Pleuronectes japonicus</i>	80.14	18.42	.20			1.24
	<i>Plecoglossus altivelis</i>	78.90	17.66	1.89			1.55
	<i>Pollachius brandii</i> (cod), salted.....	77.70	18.60	.15			3.55
	<i>Salanx microdon</i>	79.39	18.73	.30			1.58
a	<i>Scombera japonica</i> (Spanish mackerel).....	72.50	21.10	4.88			1.52
	<i>Scombrops chelodipteroides</i>	74.71	17.95	6.20			1.14
	<i>Scomberomorus sinensis</i>	77.78	19.21	1.66			1.35
a	<i>Selachoides</i>	73.59	24.82	.50			1.09
a	<i>Seriola quinqueradiata</i> (yellow tail).....	77.90	19.98	.91			1.21
a	<i>Seriola quinqueradiata</i>	75.43	21.96	1.45			1.16
	<i>Seriola purpurascens</i>	76.43	21.12	.88			1.57
	<i>Sillago</i> sp.....	79.99	18.09	.60			1.32
a	<i>Sparus schlegelii</i> (gilt head).....	74.74	22.14	1.72			1.40
a	<i>Symnosaida affinis</i> (bonito).....	72.73	25.06	1.21			1.00
a	<i>Thunnus schlegelii</i> (tunny) lean.....	77.00	17.07	4.51			1.42
a	<i>Thunnus schlegelii</i> (tunny), fat.....	71.75	15.79	10.64			1.82
a	<i>Trachurus japonicus</i> (horse mackerel).....	76.72	21.00	.75			1.53
	<i>Urostia japonica</i>	75.29	22.37	.87			1.47
a	Bonito flesh, dried.....	14.27	75.60	5.11			5.02
	Herring spawn, dried.....	77.66	20.64	1.25			.45
	<i>Shellfishes:</i>						
	<i>Area inrata</i>	82.04	15.79	.45			1.72
a	<i>Corbicula atrata</i>	79.57	18.40	.84			1.19
a	<i>Cythera meretrix</i>	84.12	13.19	.61			1.88
a	<i>Haliotis gigarista</i> (ear shell).....	73.00	24.58	.44			1.98
	<i>Macra sulcata</i>	86.16	11.08	.56			2.20
a	<i>Ostrea taiwanensis</i> (oyster).....	89.89	8.45	.89			.77
	<i>Tapes philippinarum</i>	84.07	13.20	.77			1.96
a	Kamaboko.....	70.37	20.89	.07	6.24		2.43
	<i>Vegetable food.</i>						
	<i>Cereals:</i>						
a	Barley.....	12.35	9.97	1.63	73.00	1.64	1.41
a	Barley, cooked.....	76.06	3.77	.23	18.74	.77	.43
a	Buckwheat flour.....	12.90	13.13	2.72	68.66	1.16	1.43
a	Millet (<i>Panicum miliaceum</i>).....	13.60	10.37	3.60	69.72	.91	1.87
	Millet (<i>Panicum crus-galli</i>).....	13.23	8.97	.98	72.98	3.01	.83
a	Millet (<i>Setaria italica</i>).....	13.34	11.57	5.55	65.34	1.65	2.55
	Millet (<i>Setaria italica</i>), cooked.....	58.80	4.96	.27	31.97	.76	.79
a	Rice, cleaned (kaga).....	20.14	6.56	.34	72.26	.40	.30
a	Rice, cleaned (minobu).....	19.69	8.14	.20	71.13	.48	.36
a	Rice, cleaned (higo).....	20.56	5.77	.32	72.46	.45	.44
a	Rice, cooked, average of 4.....	64.09	3.16	.05	32.26	.28	.16
a	Wheat flour, first grade.....	14.97	11.70	.97	71.03	.76	.57
a	Wheat flour, second grade.....	14.06	13.74	1.41	69.02	1.04	.73
a	Bread, average of 4.....	37.78	6.95	.12	53.46	.95	.74

TABLE 5.—Percentage composition of Japanese food materials analyzed by Tahara and associates—Continued.

Reference No.	Food materials.	Water.	Protein.	Fat.	Carbohydrates.		Ash.
					Nitrogen-free extract.	Crude fiber.	
	<i>Vegetable food—Continued.</i>						
	<i>Cereals—Continued.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per cent.</i>		<i>Per ct.</i>
a	Fu, fresh.....	71.46	13.31	0.17	14.53	0.15	0.38
a	Macaroni, dried.....	17.70	11.90	.55	63.87	.44	5.54
a	Macaroni, cooked.....	68.32	4.86	.10	25.93	.26	5.53
a	Vermicelli.....	19.58	8.45	.74	65.78	.29	5.16
a	Vermicelli, cooked.....	78.96	2.45	.07	17.11	.12	.29
a	Konnyaku.....	96.15	.01	.....	3.10	.26	.48
	<i>Legumes and their preparations:</i>						
a	Beans (<i>Phaseolus mungo subtrilobata</i>).....	12.70	22.01	.40	55.39	6.44	3.06
a	Do.....	17.00	22.97	.38	51.67	4.44	3.54
a	Beans (<i>Phaseolus mungo radiatus</i>).....	11.85	25.59	.70	53.60	5.01	3.25
a	Beans (<i>Phaseolus vulgaris</i>).....	17.51	20.30	1.07	53.19	4.46	3.47
a	Beans (<i>Vicia faba</i>).....	15.76	28.88	1.29	49.74	1.22	3.11
a	Beans, soy (<i>Glycine hispida</i>), black.....	11.09	40.25	18.26	21.97	3.88	4.55
a	Beans, soy (<i>Glycine hispida</i>), white.....	13.46	36.71	17.43	24.93	2.47	5.00
a	Beans, soy (<i>Glycine hispida</i>), green.....	12.28	42.85	13.58	23.68	2.91	4.70
a	Peas.....	14.93	23.09	.56	51.03	7.30	2.49
a	Miso, white.....	55.97	11.12	4.92	14.02	3.83	10.14
a	Miso, red, salty.....	48.54	15.42	5.94	11.36	4.72	14.02
a	Miso, red, less salt.....	51.50	10.71	6.04	19.15	4.50	8.10
7	Natto.....	61.82	19.26	8.17	6.09	2.80	1.86
a	Tofu.....	88.79	6.55	2.95	1.05	.02	.64
a	Tofu, fried.....	57.40	21.96	18.72	1.49	.08	1.35
a	Tofu, cake.....	85.66	3.66	.84	6.35	2.90	.59
a	Yuba.....	22.85	51.60	15.62	6.65	.46	2.82
	<i>Vegetables:</i>						
a	<i>Aralia cordata</i>	95.10	1.06	.10	2.47	.70	.57
a	Arrowhead.....	69.28	4.27	.20	24.36	.45	1.44
a	Bamboo shoot.....	90.26	1.82	.12	5.64	1.42	.74
a	Beans (<i>Phaseolus vulgaris</i>), unshelled and green.....	88.53	3.68	.20	3.80	2.88	.91
a	Beans (<i>Canavalia ensiformis</i>), unshelled and green.....	88.96	2.39	.14	5.32	2.28	.91
a	Beans (<i>Dolichos lablab</i>), unshelled and green.....	92.16	2.26	.15	2.35	2.46	.62
a	Bracken (<i>Pteridium aquilinum</i>).....	91.18	2.83	.13	1.41	3.27	1.18
a	<i>Brassica chinensis</i> , average of 4.....	93.98	2.20	.38	.78	1.49	1.17
a	Burdock (<i>Arctium lappa</i>).....	70.53	1.36	.07	25.23	2.18	.63
a	Carrots.....	89.12	1.25	.35	7.41	1.10	.77
a	Cucumber.....	96.64	.85	.08	1.96	.....	.47
a	Eggplant.....	94.00	1.00	.06	3.11	1.41	.42
a	Gourd (<i>Lagenaria dasystemon</i>).....	97.42	.26	.02	1.72	.35	.23
a	Jerusalem artichoke.....	79.61	2.21	.09	17.84	.....	.25
a	Lily bulb.....	69.63	3.34	.11	24.15	1.42	1.35
8	Lotus rhizome.....	85.39	1.70	.08	10.86	.84	1.13
a	Mushroom, dried (<i>Agaricus</i> sp.).....	14.59	11.63	1.68	67.73	.....	4.37
a	Mushroom, fresh (<i>Agaricus</i> sp.).....	81.73	3.73	.76	12.78	.....	1.00
a	Muskmelon.....	92.44	1.15	.48	4.10	1.24	.59
9	Onion (<i>Allium fistulosum</i>).....	92.63	1.47	.07	4.33	1.06	.44
a	<i>Osmunda regalis</i> , dried.....	6.30	20.26	.49	41.96	20.25	10.74
a	<i>Oenanthe stolonifera</i>	93.60	2.01	.13	3.22	.....	1.04
a	<i>Petasites japonicus</i>	95.60	.40	.04	2.73	.71	.52
10	Potatoes.....	76.80	1.49	.10	19.22	1.36	1.03
11	Radish (<i>Rhaphanus sativus</i>).....	94.55	.73	.01	3.70	.52	.49
a	Squash.....	90.24	.65	.13	6.08	2.15	.75
a	Spinach.....	93.91	2.30	.27	1.65	.57	1.30
a	Sweet potatoes.....	66.28	1.35	.19	28.77	2.48	.93
12	Taro.....	85.20	1.40	.08	11.70	.63	.99
a	Taro stem, dried.....	22.34	4.08	2.09	41.03	21.63	8.83
a	Turnips.....	94.00	1.62	.07	2.82	.71	.78
a	Yam (<i>Dioscorea japonica</i>).....	76.20	2.75	.12	17.97	1.79	1.17
a	Yam (<i>Dioscorea batatas</i>).....	80.32	2.85	.11	14.71	.75	1.26
a	Yatsugashira (<i>Dioscorea</i> sp.).....	68.81	2.78	.29	25.69	1.15	1.28
a	Brassica greens, pickled.....	91.25	2.21	.31	3.52	2.22	.48
13	Takuwan—radish, pickled.....	82.72	1.38	.06	6.01	1.53	8.30
	<i>Algae:</i>						
a	<i>Cystophyllum lusiforme</i> , dried.....	15.74	11.37	.49	54.84	.....	17.56
a	<i>Ecklonia bicyclis</i> , dried.....	18.75	9.58	.46	51.63	9.79	9.79
a	<i>Enteromorpha linza</i> , dried.....	13.53	19.35	1.73	46.18	.....	19.21
a	<i>Laminaria</i> sp., dried.....	23.08	7.11	.87	47.70	.....	21.24
a	<i>Porphyra laciniata</i> , dried.....	13.98	33.75	1.30	41.22	.....	9.75
a	<i>Ulopteryx pinnatifida</i> , dried.....	18.92	11.61	.31	37.81	.....	31.35

TABLE 6.—Composition of Japanese food materials analyzed in connection with investigations here compiled.

Reference No.	Investigator.	Food materials	Refuse.	Water.	Protein (N×6.25).	Carbohydrates.			Ash.
						Fat.	Nitrogen-free extract.	Crude fiber.	
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Animal food.									
14	Amaya and Kirisawa.	Beef			20.05	(5.19)			
15	Kumagawa.	Beef ^a			(20.54)	(1.78)			
16	Osawa and Ueda.	Beef extract ^b		31.24	43.13		11.56		14.07
17	Kawanishi.	do. ^b			(8.03)				
18	Osawa and Ueda.	Beef soup		96.34	2.63		.21		.82
19	do.	Fish:							
20	Murai and Kasama	Cod, dried (water-free)		(c)	95.28	0.46			2.18
21	Osawa and Ueda.	<i>Decapterus muroadsi</i> , dried	22.03	10.37	62.21	4.30			20.70
22	Murai and Kasama	Herring, dried		(d)	90.23	5.39			1.63
23	Tsuboi.	Kusaya-Aji, dried	28.44	25.92	55.02	3.50			14.12
24	Murai and Kasama.	Mackerel, dried		49.52	(38.74)	(8.96)			(2.79)
25	Kumagawa.	<i>Odopus octopodia</i> , cooked		71.76	22.12	1.48			2.72
26	Osawa and Ueda.	Pike ^a			(18.34)	(0.51)			5.95
27	do.	Porgy (water-free)		(e)	91.16	1.92			4.51
28	Amaya and Kirisawa.	Salmon (water-free)		(f)	82.45	10.84			
29	do.	Salmon			(21.60)	(12.72)			
30	Murai and Kasama	Salmon, salted		82.30	12.76	1.08			2.09
31	Tsuboi.	<i>Tapes philippinarum</i>		78.94	(18.97)	(0.33)			(1.75)
32	do.	Calamary, cooked		78.67	6.17		13.40		1.76
33	Kumagawa and Kaneda.	Hamper		5.40	27.61	11.10		52.26	3.63
34	Murai and Kasama.	"Health"		71.98	22.32	.25		3.44	2.00
35	Tsuboi.	Kanaboko		88.62	3.10	.19		6.62	1.46
36	Kumagawa and Kaneda.	Miscellaneous fish dish.		88.42	3.15	3.95		3.70	.78
		Milk							

^a The experiment by Kumagawa was made in Germany, and several of the food materials that he used were grown in Germany.

^b No figures were given for the proportions of nitrogen in proteid and nonproteid forms; but if the material was like most of the so-called beef extracts the larger part of the nitrogen was in cleavage products represented by kreatin and its congeners, and but little in the form of proteids. The figures used by Kawanishi for percentage of protein in beef extract (8.03) was taken from data given by Rubner (Ztschr. Biol., 1879, p. 141); but according to the compiler's interpretation this is the percentage of nitrogen rather than of protein; the latter should be 8.03×6.25 , or 50.19.

^c The fish when ready for cooking contained 74.78 per cent water.

^d The fish when ready for cooking contained 52.04 per cent water.

^e Percentage of water-free substance, 18 analyses: Minimum 20.52, maximum 24.58, average 21.22.

^f Percentage water-free substance, 8 analyses: Minimum 24.58, maximum 26.88, average 25.79.

TABLE 6. — *Composition of Japanese food materials analyzed in connection with investigations here compiled—Continued.*

Reference No.	Investigator.	Food materials.	Refuse.	Carbohydrates.				Ash.
				Water.	Protein (N × 6.25).	Fat.	Nitrogen-free extract.	Crude fiber.
			Per cent.	Per cent. (a)	Per cent.	Per cent.	Per cent.	Per cent.
<i>Vegetable food.</i>								
<i>Cereals:</i>								
37	Osawa and Ueda.	Barley, boiled (water-free)	.....	.....	10.93	1.19	82.70	3.88
38	Murai and Kasama.	Barley, rolled.	.....	.....	7.25	.24	67.89	1.31
39	do.	Barley, cracked.	.....	.....	7.14	.15	67.24	1.23
40	Washitsu and Uki.	Buckwheat flour.	.....	11.34	8.13	1.22	77.69	1.62
41	Osawa and Ueda.	Rice, cooked (water-free)	.....	(b)	7.90	.38	91.32	1.62
42	Suchi.	Do.	.....	.....	7.00	.92	91.28	.40
43	Amaya and Kirisawa.	Rice, cleaned.	.....	.....	7.91	(1.07)	(75.30)	.80
44	do.	Do.	.....	.....	6.49	(1.07)	(75.30)	.....
45	do.	Do.	.....	.....	6.53	(1.07)	(75.30)	.....
46	Nakasawa.	Do.	.....	25.87	9.03	.30	64.58	.....
47	Kumagawa and Kaneda.	Do.	.....	17.59	7.05	.38	74.78	.22
48	Murai and Kasama.	Do.	.....	.....	3.95	.59	76.63	.32
49	Kumagawa.	Do.	.....	83.05	6.18	(0.33)	(74.80)	.....
50	Ito and Washitsu.	Rice gruel.	.....	83.05	1.27	.55	15.23	.09
51	do.	Do.	.....	87.81	1.62	.55	14.21	.22
52	do.	Do.	.....	.....	1.27	.36	15.23	.22
53	do.	Rice, cooked.	.....	.....	.97	.12	11.02	.08
54	do.	Do.	.....	.....	2.52	.31	31.10	.24
55	Kano and Iishima.	Rice and barley, cooked.	.....	65.59	2.74	.31	31.12	.27
56	Tsuboi.	Bread, dry.	.....	65.32	3.23	.71	29.16	.45
57	Kawanishi.	Buckwheat preparation—soba.	.....	66.01	4.55	.29	e 88.12	.87
58	Kano and Iishima.	Buckwheat preparation—sobakiri.	.....	65.67	2.41	.....	(31.47)	.....
59	Fu (Kingyo).	Fu (Kiri).	.....	9.40	7.71	1.20	80.24	1.45
60	do.	Macaroni.	.....	14.91	57.35	.98	25.69	.89
61	Kawanishi.	Do.	.....	38.96	27.59	.47	32.25	.85
62	do.	Mochi.	.....	5.13	10.50	.58	82.83	.96
63	Tsuboi.	Do.	.....	6.00	12.13	.52	80.72	.75
63a	do.	Do.	.....	45.33	(3.75)	(0.88)	(46.27)	.21
64	R. Mori.	Mochi, frozen.	.....	46.82	5.18	.22	47.57	.95
65	Kawanishi.	Vermicelli.	.....	17.87	17.87	1.30	62.18	1.60
66	do.	Do.	.....	8.80	12.16	.58	76.86	1.63
<i>Sugars, starches, etc.:</i>								
67	Osawa and Ueda.	Starch.	.....	15.09	.....	.....	83.40	.....
68	Kano and Iishima.	Starch (from <i>Erythronium dens-canis</i>).	.....	18.21	.57	.05	80.89	.28
69	do.	Starch (from <i>Pueraria thunbergiana</i>).	.....	17.42	.68	.05	81.58	.27
70	Osawa and Ueda.	Sugar.	.....	4.70	.....	.....	94.07	.50
71	do.	Ame.	.....	17.81	.....	.....	81.47	.72
72	Kano and Iishima.	Konnyaku.	.....	96.68	.07	.01	2.53	.33
73	Tsuboi.	Monaka-cake.	.....	34.17	4.58	3.11	55.38	2.76

Legumes and their preparations:						
	Beans, cooked (water-free).....	40.61	18.49	32.24	4.09	4.57
	Miso.....	20.57	10.43	20.74		2.87
	Do.....	13.59	(5.94)	(11.36)		
	Do.....	11.68	(5.94)	(11.36)		
	Do.....	11.16				
	Do.....	13.06	(5.94)	(11.36)		
	Shoyu.....	(8.44)		(5.10)		16.88
	Do.....	7.56		(4.06)		
	Do.....	8.34				
	Do.....	5.62				
	Do.....	4.45				
	Do.....	8.90				
	Tofu (water-free).....	60.19	23.84	(3.10)		4.28
	Tofu, broiled.....	(10.25)	(4.61)	11.69		(1.00)
	Tofu.....	82.47	4.41	1.67		.71
	Tofu, cake—kara.....	87.80	4.40	2.43	.11	.74
	Yuba.....	83.32	6.80	16.16	.36	1.62
	Yuba.....	13.78	20.38			
	Yuba.....	47.69				
	Vegetables:					
	Arrowhead.....	25.76				
	Bamboo shoot.....	74.01	.28	20.11	.65	1.24
	Burdock.....	91.80	1.66	2.07	.86	.78
	Carrots.....	77.04	.20	15.36	2.14	.89
	Do.....	90.53	.33	6.28	1.12	.88
	<i>Ecklonia bicytis</i> , dried.....	55.62	4.96	13.60	19.16	6.26
	Eggplants.....	92.69	.10	5.02	.84	.52
	Gourd.....	95.86	1.00	1.48	.68	.90
	Kampyo.....	29.91	4.47	53.77	6.74	4.50
	Kano and Iishima.....	52.96	4.11	29.68	5.25	6.56
	Muria and Kasama.....	68.26	2.80	19.50	3.29	5.67
	Laminaria, dried.....	89.44	.09	8.67	.34	.49
	Do.....	35.10	1.23	.08	1.34	.74
	Lily bulb.....	21.57	18.74	8.80	14.45	4.31
	Lotus rhizome.....		1.93	45.41		
	Mushrooms.....	31.33	(0.09)			
	Onion.....	18.95		(11.60)		
	<i>Osmunda regalis</i>	85.68	3.34	7.30	2.68	.55
	Potatoes.....	80.16	.47	19.96	.39	.93
	Pumpkins.....	84.01	.19	11.93	1.30	.63
	Radish.....	91.62	.13	4.37	1.61	1.02
	Do.....	80.77				
	Stachys.....	76.15				
	<i>Stachys sieboldi</i>	14.66				
	Kano and Iishima.....	1.27	.20	20.34	.79	1.24

^a Percentage water-free substance, 18 analyses: Minimum 20.31, maximum 24.73, average 23.65.
^b Percentage water-free substance, 24 analyses: Minimum 30.53, maximum 38.02, average 34.16.
^c Including 17.86 per cent sugar.

^d Percentage water-free substance, 10 analyses: Minimum 11.44, maximum 17.56, average 14.56.

^e This figure was obtained by difference. The investigators repeated the analyses several times, and obtained results that agreed very closely. The usual test with iodine for starch, and the test for reducing sugar after treatment with HCl both gave negative results, and the investigators therefore considered this difference as a probable error in analysis. However, since the carbohydrates in soy bean are largely if not entirely galactan, the iodine test can not be considered as final.—K. O

^f Including 26.82 per cent sugar.

^g The experiment by Kumagawa was made in Germany, and several of the food materials that he used were grown in Germany.

^h Including 4.38 per cent sugar.

TABLE 6.—Composition of Japanese food materials analyzed in connection with investigations here compiled—Continued.

Reference No.	Investigator.	Food materials.	Refuse.	Water.	Protein. (N×6.25).	Fat.	Carbohydrates.		
							Nitrogen-free extract.	Crude fiber.	Ash.
		<i>Vegetable food—Continued.</i>							
		<i>Vegetables—Continued.</i>							
113	Kawanishi.	Sweet potatoes, partially dried.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
114	Kano and Iishima.	Taro.	4.96	1.71	0.76	82.62	7.65	2.30	
115	Murai and Kasama.	Taro stem, dried.	83.22	1.41	.34	13.27	.76	1.00	
116	Kunagawa.	Turnips ^a .	88.01	.59	(0.18)	6.48	3.82	.94	
117	Murai and Kasama.	<i>Uolperiz pinnatifida</i> , dried.		.65		33.71	(7.36)		7.47
118	Kano and Iishima.	Yam.	54.79	1.09	.32	11.14	2.62	7.76	
119	Taubol.	Ginger pickled in miso.	85.46	1.55	.23	9.49	.86	13.40	
120	do.	Miscellaneous vegetable dish.	45.12	1.49	1.06	45.15		.67	
121	Osawa and Ueda.	Mustard.		(27.99)	(29.38)	(17.63)	(12.29)	(4.18)	
122	do.	Pepper.		(12.00)	(8.92)	(43.02)	(14.49)	(4.59)	
123	Kunagawa and Kaneda.	Pickles.	62.51	7.48	.74	10.79		18.48	
124	Taubol.	Radish pickled in miso.	74.08	4.90	.32	9.36		11.34	
		<i>Beverages:</i>							
125	Kunagawa	Beer.		.53		8.93			
126	Amaya and Kirisawa.	Sake.		1.21		b (22.30)			
127	Kunagawa.	Tea decoction.		.08					
127a	Amaya and Kirisawa.	Do.		.07					
128	Kellner and Y. Mori.	Composites of food.							
129	do.	do.	75.64	c 3.30	.54	19.42	.81	1.29	
130	do.	do.	65.80	d 6.07	1.08	25.62	.25	1.18	
131	do.	do.	61.33	e 8.20	1.38	27.31	.40	1.38	
132	do.	do.	83.62	4.95	2.07	5.16	1.10	3.10	
133	do.	do.	87.76	3.72	2.61	.84	1.20	1.87	
134	do.	do.	73.69	9.67	4.52	7.34	1.21	3.57	
135	do.	do.	81.38	.90	.12	11.26	2.75	3.68	
136	Eljmann.	do.	69.69	9.18	4.40	33.62		.26	
137	do.	do.	63.24	2.76	1.12	5.43		2.62	
138	do.	do.	85.82	4.60	1.53	29.76	.41	.42	
139	do.	do.	66.00	3.12	.29	6.50	1.54	4.15	

^a The experiment by Kunagawa was made in Germany, and several of the food materials that he used were grown in Germany.^b Contained 9.76 per cent dextrin and glucose, and 12.45 per cent alcohol. The latter is isodynamic with (12.45×1.78=) 21.54 per cent carbohydrates, therefore the total carbohydrates is given as (21.54×0.76=) 22.30 per cent.^c 20.2 per cent of total nitrogen in nonprotein.^d 11.4 per cent of total nitrogen in nonprotein.^e 9.0 per cent of total nitrogen in nonprotein.

FOOD CONSUMPTION IN JAPAN.

The Japanese dietary studies are considered in this section, the tabular matter being preceded by a brief preliminary discussion of the general dietary customs of the Japanese, which will probably afford a clearer interpretation of the investigations.

NATURE OF THE DAILY FOOD.

Three meals a day are commonly eaten; one after rising, one at midday, and one about sunset; though in the rural districts four or five meals are not uncommonly taken. The first meal of the day is usually the lightest; the heartiest meal, i. e., dinner, is generally in the evening; but all three meals are largely of a similar nature. Rice is the principal item at every meal,^a wherever it can be afforded (see p. 18), but it is usually supplemented by other foods, some of the soy-leavened preparations being an essential part of the diet.

Among the foods commonly eaten in addition to the rice—designated as “supplemental food” in many of the dietary studies beyond—are miso or shoyu soup, cooked vegetables, fish, and pickles. Vegetables or fish, or both, are commonly used for soup making. Miso soup containing vegetables is an indispensable part of breakfast in most households, cabbage, onion, potato, and radish being the common ingredients. Tofu and eggs are often used in the same way among the better classes. Takuwan, or radish pickled in rice bran, is the commonest kind of pickle. Tea is usually served at the end of each meal, though to a very small extent an infusion of roasted barley is used instead of tea. Nothing corresponding to desserts is used in the Japanese diet. Various kinds of cake are made, but these are usually served with tea between regular meals. Sake is often served with dinner, at the beginning of the meal, and is generally taken hot.

For feasts and entertainments there are many special dishes, among them being preparations from glutinous rice. Mochi (see p. 21) is the commonest of such articles for New Year's feasts. Glutinous rice steamed in combination with adzuki bean, previously cooked in water, is very generally used on special occasions. Among ordinary families in the rural districts the use of meat is (of necessity) restricted chiefly to festival occasions; and among the poorer peasantry even rice is used only at such times.

PREPARATION OF DAILY FOOD.

The ordinary daily preparation of food is in general not at all complicated. In the large majority of families the appliances for cooking

^a Very naturally the Japanese expression “go-han” or “meshi” for cooked rice is used in much the same sense as this English term “meal.” In the Japanese equivalent for the statement “dinner is served,” the term “go-han” would be used.

are few and simple. Anything corresponding to a kitchen range or oven is rarely seen, even in the houses of the well-to-do. Most of the kitchen utensils so common in the United States and Europe have practically no counterpart in the ordinary Japanese kitchen. Indeed, in many houses the kitchen fireplace has not even a chimney. However, since much of the cooking is done with charcoal, the chimney is less necessary than would otherwise be the case.

Rice is commonly prepared for daily use simply by cooking with water. Barley and millet are also cooked with water, but very generally in combination with rice, though such combinations are more common in the rural districts than in cities and towns. Among well-to-do families the rice-barley combination is used only occasionally, and more as a delicacy, being eaten with tororo, a mucilaginous sauce made from grated yam and shoyu containing bonito extract.

A few food materials, such as those just mentioned, are cooked simply in water, and flavored with shoyu when eaten; but the common American or European practice of cooking vegetables in this way, to be eaten with sauce added after cooking, is rarely followed in Japan, the flavoring materials being almost always added during the cooking. In the cooking of both animal and vegetable foods, either miso or shoyu is used. Where miso is used, however, it is generally intended for more than a flavoring material, the cooked product being a soup with the miso as a basis, so that the miso in a way corresponds in purpose, though not in character, to "soup stock." In all other cases shoyu is used, commonly in combination with dried bonito and sugar. In some cases the shoyu is added during cooking, and in others the materials are cooked in shoyu.

Certain vegetables, such as edible burdock, carrots, and potatoes, as well as fish, are commonly fried, especially in winter, usually in combination with wheat flour and forming what is generally known as "tempura," which are like fritters. The wheat flour is mixed with water and beaten egg into a sort of thick dough, and into this are put thin slices of the fish or the vegetables. The little rolls are then fried in vegetable oil, rape-seed oil being commonly used for this purpose, though preference is given to sesame-seed oil for finer cooking.

Cucumber is almost the only vegetable or plant used as salad.

The leaves and stems of Chinese cabbage (*Brassica chinensis*) are sometimes boiled in water and eaten with shoyu, but they are chiefly used for making pickles, some form of pickles being considered almost a necessary part of every meal.

Though the larger part of the leguminous food in the Japanese diet consists of the preparations of soy beans, such as miso, shoyu, and tofu, some legumes are cooked in their natural state, chiefly peas, mungo beans, and certain varieties of soy beans. They are simply boiled in water until very soft and then seasoned with shoyu and sugar.

As in other oriental countries, the knife and fork are not customarily used in Japan, consequently all food materials must be so prepared that they can be easily handled with chopsticks. For this reason meats are almost always cooked in small pieces, most commonly either with shoyu and sugar, or in a stew with vegetables. The roasting of meat is practically unknown, except where occidental methods have been adopted, though broiling over charcoal fire is quite common, especially in the cooking of fish.

Fish is commonly eaten either boiled or broiled, though a few kinds are eaten raw—for example, halibut, dab, porgy, and tunny. Several special fish preparations are also used (see p. 19). In the case of the raw fish the skin and bones are carefully removed and the flesh is cut into small pieces and eaten with shoyu and a little grated radish or horseradish. It is considered very palatable and believed to be easily digested. The only objection is the danger of parasites in the flesh. It has been found, however, that parasites are very rarely present in the kinds of fish that are used in this way. In broiling, which is done over a charcoal fire, a little salt is usually sprinkled on the fish (or meat) before cooking. Broiled eel is one of the most highly prized of fish foods. In cooking fish with shoyu the usual method is to heat the sauce until it boils before the fish is put in.

STUDIES OF FOOD CONSUMPTION.

Following is a list or catalogue of the investigations in which the object was to determine the kinds and amounts of nutrients in the food consumed by people in different circumstances in Japan. The order in which the studies are given in this list is that of the date of publication. It is impossible to say whether this is also the order in which the investigations were made, because in many of the reports the dates at which the investigations were conducted were not stated. The serial numbers in the first column are those by which the studies are designated in the following pages.

TABLE 7.—List of dietary studies.

Serial No.	Date of publication.	Observer.	Subject. Occupation.	Number.	Dura- tion.	Food.	Remarks.
1	1882	Scheube	Student.	1	Days	Mixed vegetable and animal diet	Reported by committee for investigation of kakke disease in the navy Do. Do. Do.
2	1882	do.	do.	1	5	do.	
3	1882	do.	Nurse.	1	5	do.	
4	1885	Navy medical bureau.	Marines.	284-309	271	Navy ration.	
5	1885	do.	Cadets.	27	271	do.	Cited by Tahara. Do. Digestion experiment No. 13 and nitrogen metabolism experiment No. 13 Digestion experiment No. 14 and nitrogen metabolism experiment No. 14 Digestion experiment No. 15 and nitrogen metabolism experiment No. 15.
6	1885	do.	Underofficers.	27	271	do.	
7	1885	do.	Officers.	15	222	do.	
8	1886	Eijkman	Military cadets.	7	7	Mixed vegetable and animal diet	
9	1886	do.	Prisoners without work.			Vegetable diet with barley.	Digestion experiment No. 20 and nitrogen metabolism experiment No. 20 Digestion experiment No. 21 and nitrogen metabolism experiment No. 21 Digestion experiment No. 22 and nitrogen metabolism experiment No. 22 Digestion experiment No. 23 and nitrogen metabolism experiment No. 23 Digestion experiment No. 25 and nitrogen metabolism experiment No. 25
10	1886	do.	Prisoners with light work.		7	do.	
11	1886	do.	Prisoners with heavy work.		7	do.	
12	1887	Tahara	Students.	130	10	Mixed vegetable and animal diet	
13	1887	do.	Pupils.	69	7	do.	Cited by Tahara. Do. Digestion experiment No. 13 and nitrogen metabolism experiment No. 13 Digestion experiment No. 14 and nitrogen metabolism experiment No. 14 Digestion experiment No. 15 and nitrogen metabolism experiment No. 15.
14	1887	do.	do.	59-66	7	do.	
15	1887	do.	Store employees.	72-85	7	do.	
16	1887	do.	Physiologist.	1		do.	
17	1887	Oswa.	Chemist.	1	31	Navy ration.	Digestion experiment No. 20 and nitrogen metabolism experiment No. 20 Digestion experiment No. 21 and nitrogen metabolism experiment No. 21 Digestion experiment No. 22 and nitrogen metabolism experiment No. 22 Digestion experiment No. 23 and nitrogen metabolism experiment No. 23 Digestion experiment No. 25 and nitrogen metabolism experiment No. 25
18	1887	Isihara.	Marines.	1	6	Mixed vegetable and animal diet	
19	1887	Keller and Y. Mori.	Chemist.	1	6	do.	
20	1887	do.	do.	1	6	do.	
21	1887	do.	do.	1	6	Mixed vegetable diet, with barley.	Digestion experiment No. 20 and nitrogen metabolism experiment No. 20 Digestion experiment No. 21 and nitrogen metabolism experiment No. 21 Digestion experiment No. 22 and nitrogen metabolism experiment No. 22 Digestion experiment No. 23 and nitrogen metabolism experiment No. 23 Digestion experiment No. 25 and nitrogen metabolism experiment No. 25
22	1888	Tanboi	School business agent.	1	10	Mixed vegetable and animal diet	
23	1888	do.	Physician.	1	2	do.	
24	1888	do.	Rice cleaner.	1	3	do.	
25	1889	do.	Merchant.	1	10	do.	Digestion experiment No. 20 and nitrogen metabolism experiment No. 20 Digestion experiment No. 21 and nitrogen metabolism experiment No. 21 Digestion experiment No. 22 and nitrogen metabolism experiment No. 22 Digestion experiment No. 23 and nitrogen metabolism experiment No. 23 Digestion experiment No. 25 and nitrogen metabolism experiment No. 25
26	1889	do.	do.	1	4	do.	
27	1889	do.	Irishman.	1	13	do.	
28	1889	Kumagawa.	Physician.	1	5	do.	
29	1889	do.	do.	1	5	Mixed vegetable diet.	Digestion experiment No. 20 and nitrogen metabolism experiment No. 20 Digestion experiment No. 21 and nitrogen metabolism experiment No. 21 Digestion experiment No. 22 and nitrogen metabolism experiment No. 22 Digestion experiment No. 23 and nitrogen metabolism experiment No. 23 Digestion experiment No. 25 and nitrogen metabolism experiment No. 25
30	1889	do.	do.	1	9	do.	
31	1890	Tanboi and Murata	Physician.	1	3	Mixed vegetable and animal diet	

32	1890	do	Laboratory assistant	1	3	do	Digestion experiment No. 26 and nitrogen metabolism experiment No. 26
33	1890	do	Student	1	3	do	Digestion experiment No. 27 and nitrogen metabolism experiment No. 27
34	1891	Yamashita	Marines	1	61	Navy ration	Digestion experiment No. 28 and nitrogen metabolism experiment No. 28
35	1891	Amaya and Kiraawa	Laboratory assistant	1	10	Mixed vegetable and animal diet	Digestion experiment No. 29 and nitrogen metabolism experiment No. 29
36	1891	do	Physician	1	7	do	Digestion experiment No. 30 and nitrogen metabolism experiment No. 30
37	1891	do	Laboratory assistant	1	7	do	Digestion experiment No. 31 and nitrogen metabolism experiment No. 31
37a	1891	do	do	1	6	do	Digestion experiment No. 32 and nitrogen metabolism experiment No. 32
38	1891	do	do	1	10	Mixed vegetable diet with legumes	Digestion experiment No. 33 and nitrogen metabolism experiment No. 33
39	1892	do	do	1	5	Mixed vegetable diet	Digestion experiment No. 34 and nitrogen metabolism experiment No. 34
40	1892	do	do	1	7	do	Digestion experiment No. 35 and nitrogen metabolism experiment No. 35
41	1892	do	Physician	1	6	do	Digestion experiment No. 36 and nitrogen metabolism experiment No. 36
42	1892	do	do	1	6	do	Average of 66 studies
43	1892	Army medical bureau	Infantry			Army ration	Average of 98 studies
44	1892	do	do			do	Average of 6 studies
45	1892	do	Cavalry			do	Average of 13 studies
46	1892	do	do			do	Average of 12 studies
47	1892	do	Artillery			do	Average of 14 studies
48	1892	do	do			do	Average of 13 studies
49	1892	do	Engineers			do	Average of 19 studies
50	1892	do	do			do	Average of 8 studies
51	1892	do	Provision corps			do	Average of 12 studies
52	1892	do	do			do	Average of 2 studies
53	1892	do	Cadets			Mixed vegetable and animal diet	Average of 3 studies
54	1892	do	do			do	Digestion experiment No. 37
55	1892	do	do			do	Digestion experiment No. 38
56	1892	do	do			do	Digestion experiment No. 39
57	1892	do	do			do	Digestion experiment No. 40
58	1892	do	do			do	Digestion experiment No. 41
59	1892	Taniguchi	Laboratory servant	1	2	Rice and beef extract	Digestion experiment No. 42
60	1892	do	do	1	4	Rice and pickles	No. 37 and nitrogen metabolism
61	1892	do	do	1	10	Rice and miso	No. 38 and nitrogen metabolism
62	1892	do	do	1	10	Rice and vegetables	No. 39 and nitrogen metabolism
63	1892	do	do	1	10	do	No. 40 and nitrogen metabolism
64	1892	do	do	1	10	do	No. 41 and nitrogen metabolism

TABLE 7.—*List of dietary studies—Continued.*

Serial No.	Date of publication.	Observer.	Subject.		Dura- tion.	Food.	Remarks.
			Occupation.	Number.			
65	1892	Taniguchi	Laboratory servant	1	Days.	Rice and vegetables	Digestion experiment No. 43 and nitrogen metabolism experiment No. 43.
66	1892	Oi	Military nurse	40	7	Army rice ration	Digestion experiment No. 44
67	1892	do.	do.	3	3	Rice and fish	Digestion experiment No. 45
68	1892	do.	do.	3	3	Rice and tofu	Digestion experiment No. 46
69	1892	do.	do.	3	3	Rice and vegetables	Digestion experiment No. 47
70	1892	do.	do.	3	3	Rice, barley, and meat	Digestion experiment No. 48
71	1892	do.	do.	3	3	Rice, barley, and fish	Digestion experiment No. 49
72	1892	do.	do.	3	3	Rice, barley, and tofu	Digestion experiment No. 50
73	1892	do.	do.	3	3	Rice, barley, and vegetables	Digestion experiment No. 51
74	1892	R. Mori, Oi and Iishi	Soldier	1	8	Army rice ration	Digestion experiment No. 52
75	1892	do.	do.	1	8	do.	Digestion experiment No. 53
76	1892	do.	do.	1	8	do.	Digestion experiment No. 54
77	1892	do.	do.	1	8	do.	Digestion experiment No. 55
78	1892	do.	do.	1	8	do.	Digestion experiment No. 56
79	1892	do.	do.	1	8	do.	Digestion experiment No. 57
80	1892	do.	do.	1	8	Army rice, barley, ration	Digestion experiment No. 58
81	1892	do.	do.	1	8	do.	Digestion experiment No. 59
82	1892	do.	do.	1	8	do.	Digestion experiment No. 60
83	1892	do.	do.	1	8	do.	Digestion experiment No. 61
84	1892	do.	do.	1	8	do.	Digestion experiment No. 62
85	1892	do.	do.	1	8	do.	Digestion experiment No. 63
86	1892	do.	Military nurse	1	8	Army barley ration	Digestion experiment No. 64

87	1892	do.	Soldier	1	8	Army bread ration	Digestion experiment No. 64 and nitrogen metabolism experiment No. 64.
88	1892	do.	do.	1	8	do.	Digestion experiment No. 65 and nitrogen metabolism experiment No. 65.
89	1892	do.	do.	1	8	do.	Digestion experiment No. 66 and nitrogen metabolism experiment No. 66.
90	1892	do.	do.	1	8	do.	Digestion experiment No. 67 and nitrogen metabolism experiment No. 67.
91	1892	do.	do.	1	8	do.	Digestion experiment No. 68 and nitrogen metabolism experiment No. 68.
92	1892	do.	do.	1	8	do.	Digestion experiment No. 69 and nitrogen metabolism experiment No. 69.
93	1892	Oi.	Military nurse	10	12	Army rice ration	Digestion experiment No. 70 and nitrogen metabolism experiment No. 70.
94	1892	do.	do.	10	12	Army bread ration	Digestion experiment No. 71 and nitrogen metabolism experiment No. 71.
95	1892	Honda	Marines	322	204	Navy ration	Very little animal food.
96	1893	Sekiba	Coal miners	7	7	Mixed vegetable and animal diet	
97	1894	Horiguchi	Patients in military hospital	7	7	do.	
98	1894	do.	do.	7	7	Rice gruel and eggs	
99	1896	Onda	Native Formosans	3	2	Mixed vegetable diet	
100	1896	Nagase	Military colonist	1	7	do.	
101	1898	Noda (reporter)	Prisoners	1,011	7	Mixed vegetable diet, with barley	
102	1899	Nagao	Army surgeon	1	1	Army rice, barley, ration	
103	1900	Navy medical bureau	Marines	1	1	Navy ration allowance	
104	1900	do.	do.	do.	do.	do.	
105	1900	do.	do.	do.	do.	do.	Digestion experiment No. 101.
106	1900	do.	do.	do.	do.	do.	For year 1884.
107	1900	do.	do.	do.	do.	do.	For year 1885.
108	1900	do.	do.	do.	do.	do.	For year 1886.
109	1900	do.	do.	do.	do.	do.	For year 1887.
110	1900	do.	do.	do.	do.	do.	For year 1888.
111	1900	do.	do.	do.	do.	do.	For year 1889.
112	1900	do.	do.	do.	do.	do.	For year 1890.
113	1900	do.	do.	do.	do.	do.	For year 1891.
114	1900	do.	do.	do.	do.	do.	For year 1892.
115	1900	do.	do.	do.	do.	do.	For year 1893.
116	1900	do.	do.	do.	do.	do.	For year 1894.
117	1900	do.	do.	do.	do.	do.	For year 1895.
118	1900	do.	do.	do.	do.	do.	For year 1896.
119	1900	do.	do.	do.	do.	do.	For year 1897.
120	1900	do.	do.	do.	do.	do.	For year 1898.
121	1900	do.	do.	do.	do.	do.	For year 1899.
		do.	do.	do.	do.	do.	For year 1900.
		do.	do.	do.	do.	do.	Allowance at sea.
		do.	do.	do.	do.	do.	Revised (1900).
		do.	do.	do.	do.	do.	Allowance on land or in harbor.
		do.	do.	do.	do.	do.	Revised (1900).

The total number of investigations of food consumption covered by the above list is 376. In the reports of the investigations made in the army, however, the results were usually given in very condensed form, and in collating the material for the present compilation it was frequently necessary to consider the average of a large number of studies as one; for example, what is here designated as study No. 44 is actually the average of the results of 98 studies. As shown in the column headed "Remarks" in Table 7, there are 13 such cases in which the number of studies included in an average and compiled as one study ranged from 2 to 98, so that 268 actual studies here appear as only 13. For this reason the serial numbers in the list do not exceed 121.

Not all of these 121 investigations are dietary studies in the ordinary sense of the term—that is, observations of the kinds and amounts of food actually eaten by people with free choice. For instance, Nos. 120 and 121 are calculations of the nutrients supplied by the revised (1900) navy ration allowance at sea and on land, and Nos. 103–119 are similar computations for the allowance in different years from 1884 to 1900, inclusive. On the other hand, in a number of investigations in which the diet was actually studied, the kinds or amounts of food were more or less controlled or prescribed, the investigations having been generally made for some special purpose, such as determinations of the daily protein requirement. Most of these latter are more strictly feeding or dietary experiments than ordinary dietary studies, and are discussed as such in a separate division of this section.

In connection with 58 of these investigations of food consumption, the digestibility of one or all of the nutrients of the diet was also determined; and in all but one of these cases the metabolism of nitrogen was estimated. These studies are indicated in the column headed "Remarks."

In some of the studies the subjects were boys or young men at school, but in most cases they were adult men, the large majority of whom were among the professional or the military classes; very few were artisans and laborers. With the exception of the officials and privates in the army and navy, nearly all were residents of cities. None of the studies included women. The number of subjects in each study ranged from 1 to 1,011 in cases in which the numbers were reported, but in many of the reports of the studies, especially those in the army and the navy, the number of subjects was not stated. The period of observation ranged from three days to a year in the cases in which the length of time was reported. The diet was generally such as is commonly eaten by persons of the class to which the subjects belonged, though in a considerable number of the studies, as explained above, the diet was experimental.

In all the studies the quantities of foods used were determined by actual weighing, except in study No. 94, in which the data were

obtained from the cook's account book. In many studies, especially those with a large number of subjects, for example No. 12, the total quantity of each food material ready for cooking was weighed before the preparation of each meal, and the quantities of nutrients were calculated from these weights, the total quantity of each nutrient divided by the number of persons at the meal showing the quantity per person for the meal. In other cases the cooked food served to each person was weighed, and also the waste left by each one. The difference showed the amount actually eaten, and from this the quantity of nutrients was calculated. The methods followed by the different investigators are stated in the descriptions of the studies.

Although the amount of waste was not reported in any of the studies, it was stated in many cases that it has been determined and deducted. In most cases where it is not mentioned it was probably insignificant. The amount of waste in the Japanese diet in general is believed to be exceedingly small.

In many of the studies analyses of the single food materials or of composites were made. In other cases the figures for percentage composition were assumed from available data regarding similar materials. Wherever the figures actually used in calculating the quantities of nutrients in the diet were reported, whether analyses made in the study or data assumed, they have been included in Table 6. The figures in parentheses following the names of the food materials in the tables of the studies on the pages beyond correspond with those in the columns designated "Reference-number" in Tables 5 and 6, and serve to indicate the values used for percentage composition of the given materials. Unfortunately in many cases neither the results of analyses nor the assumed values were reported.

The data of the studies have been tabulated, so far as possible, in the form commonly followed in the later publications of this Office. In some of the original accounts of the studies the results were reported on the basis per man per meal, but for the sake of uniformity these have all been recalculated per man per day. In making these calculations, and in verifying some of the other data, a few errors were found in the reported figures. Queries regarding these were sent to the investigators, and corrected figures were used in the compilation. Where the compiler's figures are thus used they are inclosed in parentheses to indicate it.

In so many of the studies the digestibility of one or all of the nutrients was determined that it seemed desirable to express the results of the studies in terms of digestible as well as total nutrients per man per day. In the cases where digestion experiments were made in connection with the dietary studies themselves, the amounts of digestible nutrients were obtained from the results of the experiments. Such cases are indicated in the tables. In other cases the quantities of digestible nutrients were calculated from the total nutrients by use

of the following factors for digestibility of nutrients in different diets, which are based upon the results of 125 Japanese digestion experiments summarized beyond.

TABLE 8.—*Factors for computing digestibility of Japanese dietaries.*

Kind of food.	Protein.	Fat.	Carbo- hydrates.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Ordinary mixed diet.....	87	85	98
Ordinary mixed diet with barley.....	76	85	97
Vegetable mixed diet.....	78	82	98
Vegetable mixed diet with barley.....	76	82	98

Energy was not determined in any of the studies, but in a few cases the fuel values of the diets had been calculated by use of Rubner's factors. In all the tables given beyond the fuel values were calculated by the compiler from the quantities of digestible nutrients by use of the following factors: 4.4 calories per gram of protein, 9.4 calories per gram of fat, and 4.2 calories per gram of carbohydrates in a mixed diet of vegetable and animal foods. Where the diet contained no animal foods the factor 9.3 calories per gram of fat was used, the factors for protein and energy being the same as above. These factors for fuel value were deduced from the results of the experiments here compiled, as explained in another section (p. 216).

DIETARY STUDIES.

In this division of the bulletin are given the details of the ordinary dietary studies—i. e., the observations of the kinds and amounts of food consumed by people in different circumstances in Japan.

DIETARY STUDIES WITH MEDICAL STUDENTS AND A NURSE (Nos. 1-3).

These studies were made by B. Scheube,^a a German physician then connected with the Medical School of Kyoto, assisted by Kayama and Honda. The date of the investigation was not given. The data were first published in German in 1882, and later in Japanese. The studies are interesting from a historical standpoint, being the first series ever made in Japan, so far as found on record. The results obtained were at the time frequently referred to in discussions of the food problems in Japan. It is stated in the report that nine studies in all were made by the investigator during the four years and six months that he remained in Kyoto, but only three of the studies were reported in such detail as to be available for the purpose of this compilation.

^a Mitt. Deut. Gesell. Natur- u. Völk. Ostasiens, 3 (1882), No. 27, p. 282; Arch. Hyg., 1 (1883), p. 352; Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 1 (1887), p. 26.

Each study continued five days. The subject in No. 1 was a medical student 20 years old, weighing 49 kilograms; in No. 2 the subject was a medical student 24 years old, weighing 54 kilograms; and in No. 3 the subject was a man nurse 36 years old, weighing 48.5 kilograms.

The diet consisted of both animal and vegetable foods. The amounts of animal food, including beef, fish, and eggs, in studies Nos. 1 and 2 were considerable, and even in No. 3 the diet included a relatively large amount of beef. The subjects of studies Nos. 1 and 2 paid about 20 sen (about 10 cents) daily for their meals, and with subject No. 3 the expense ranged from 8 to 10 sen (about 4 to 5 cents) daily.

The cooked food for each person was weighed at each meal. The amounts of nutrients in the food were calculated from such data regarding the composition of foods as were then available,^a although the amount of water in cooked rice was actually determined, and found to be on the average about 65 per cent, the range of variation in different determinations being very small.

The data of the studies are given in the following table:

TABLE 9.—Results of dietary studies Nos. 1–3.

Kinds and amounts of food consumed per person for five days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo-hydrates.	Fuel value.
<i>Study No. 1.</i>				
ANIMAL FOOD.				
Beef, cooked with onion, 1,072 grams; sauce, 169 grams.....	Grams.	Grams.	Grams.	Calories.
Fish and tofu, cooked, 449 grams; sauce, 14 grams; broiled fish and kamaboko, 140 grams; broiled fish, 41 grams; cooked fish, 93 grams; kamaboko, 169 grams.....				
Eggs (edible portion), 78 grams.....				
VEGETABLE FOOD.				
Rice, cooked, 5,440 grams.....				
Radish, pickled, 367 grams.....				
Tea decoction, 5,040 cubic centimeters.....				
Total food	86.0	13.2	333.6	
Total nutrients.....	74.8	11.2	326.9	1,811
Digestible nutrients.....				
<i>Study No. 2.</i>				
ANIMAL FOOD.				
Beef, cooked, 913 grams; beef and tofu, cooked, 95 grams.....				
Fish, broiled, 83 grams; fish, cooked, 215 grams; kamaboko, cooked, 93 grams; sauce, 150 grams.....				
Eggs (edible portion), 214 grams.....				
VEGETABLE FOOD.				
Rice, cooked, 8,977 grams.....				
Tofu, cooked, 501 grams.....				
Turnips, cooked, 97 grams; radish, pickled, 587 grams.....				

^a Moleschott, Gorup-Besanez, *Lehrbuch der Physiologischen Chemie*; Roth und Sex, *Handbuch der Militär-Gesundheitspflege*; Langard, *Mitt. Deut. Gesell. Natur- u. Volkerk. Ostasiens*, No. 16, Tokyo; and Kinch, *Trans. Asiatic Soc. Japan*, 11 (1883), pt. 1, p. 1.

TABLE 9.—Results of dietary studies Nos. 1-3—Continued.

Kinds and amounts of foods consumed per person for five days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 2—Continued.</i>				
VEGETABLE FOOD—continued.				
Tea decoction, 290 cubic centimeters; sake ^a 100 cubic centimeters.....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Total food { Total nutrients.....	109.8	17.8	546.3	
{ Digestible nutrients.....	95.5	15.1	535.4	2,810
<i>Study No. 3.</i>				
ANIMAL FOOD.				
Beef, 711 grams.....				
Fish, kamaboko, 170 grams; sauce, 110 grams.....				
VEGETABLE FOOD.				
Rice, cooked, 7,892 grams.....				
Onions, cooked, 784 grams; radish, pickled, 1,203 grams.....				
Total food { Total nutrients.....	74.4	6.0	479.2	
{ Digestible nutrients.....	64.7	5.1	469.6	2,305

^a The investigator took no account of the sake in computing the results of this study. Sake contains, on the average, 12.45 per cent alcohol (equivalent to 21.54 per cent carbohydrates) and 0.78 per cent dextrin, glucose, etc. The compiler allowed for 22.3 grams of carbohydrates in sake, consequently the total carbohydrates per day in this study are 4.5 grams larger in this table than in the original report.

In each study the urine was collected for the five days during which the study was made, and urea was determined by Liebig's method, the amounts found being 132.6 grams for five days for subject No. 1, or 26.5 grams per day, equivalent to 80 grams of protein. For subject No. 2 the values were 165.1 grams urea for five days, 33 grams per day, equivalent to 99 grams protein. In the case of subject No. 3, 125.5 grams urea, or 25.1 grams per day, was excreted, corresponding to 76 grams protein.

The daily income of protein as calculated from the data of the dietary study agrees fairly well, for each subject, with the average amount of protein katabolized as computed from the quantity of urea determined in the urine.

The investigators considered these dietaries as typical of those of people in different circumstances in life in Japan, Nos. 1 and 2 representing the dietaries of the fairly well to do and No. 3 that of the poorer classes. Regarding the latter assumption, however, criticism was expressed at the time. It is certainly not a very common practice among the class of people of whom subject No. 3 was assumed to be representative to use animal food, and especially beef, in such quantity as would be inferred from the results of this study.

DIETARY STUDIES WITH OFFICERS AND MARINES (Nos. 4-7).

These studies were made by a navy surgeon^a on the battle ship *Ryujō* during a long voyage. The ship left Japan on December 19,

^a Ryujokan Kakkebyo Chosasho (Report of Investigations on Beriberi on the Battle ship *Ryujō*), Navy Med. Bur., Tokyo, 1885.

1882, and after visiting New Zealand, Chile, Peru, and Hawaiian Islands, returned on September 15, 1883. On board the ship there were 309 marines, 27 cadets, 27 subofficers, and 15 officers, and separate studies, Nos. 4 to 7, respectively, were made with these groups.

The studies with the subofficers, cadets, and marines continued during the whole time of the voyage, 271 days. The duties of the officers while in harbors made it necessary for them to take their meals on land, consequently their food consumption for February 6-20, April 13-16, and May 28 could not be ascertained. The actual time of the study with this group was therefore somewhat shorter, namely, 222 days.

The data of the studies as given in the original report show the total supply of the different kinds of food for each day, and the total number of persons for each meal, for the different groups. These have been compiled in Table 10 in such a way as to show the amounts of different classes of food consumed per man per day, on an average, and the quantities of nutrients supplied. The meats used included fresh beef, corned beef and boiled beef (canned), pork, ham, chicken, etc. The fish included cod, salmon, sardines, trout, oysters, and other kinds, either fresh or preserved. The fat included butter, beef fat, and lard.

No detailed account of the waste was given in the report. It is to be inferred that the quantities of food per man per day given in the table are those supplied rather than those actually eaten, but there are reasons for believing that the amount of waste was not very large.

No analyses of food materials were made in connection with these studies. Apparently the average values for the composition of similar food materials were used in calculating the amounts of nutrients supplied, but no reference was made to the source of such data.

TABLE 10.—Results of dietary studies Nos. 4-7.

Kinds and amounts of food consumed per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 4 (marines).</i>				
ANIMAL FOOD.				
Meats, 94 grams.....	Grams. 19.4	Grams. 3.3	Grams.	Calories.
Fish, 53 grams.....	9.7	1.6	.....	.....
Eggs, 4 grams.....	.5	.5	.....	.....
Milk, 19 grams.....	.8	.7	0.9	.....
Total animal food.....	30.4	6.1	.9	.....
VEGETABLE FOOD.				
Cereals: Bread, 81 grams; rice, 612 grams.....	48.2	7.3	511.3	.....
Sugar, 35 grams.....	.....	.....	34.2	.....
Legumes and their preparations: Legumes, 19 grams; miso, 21 grams; shoyu, 58 grams.....	9.1	.4	16.9	.....
Vegetables, 193 grams.....	3.4	.6	22.6	.....
Total vegetable food.....	60.7	8.3	585.0	.....
Total food.....	91.1	14.4	(585.9)	.....
Total nutrients.....	79.3	12.2	574.2	2,875
Digestible nutrients.....				

TABLE 10.—Results of dietary studies Nos. 4-7—Continued.

Kinds and amounts of food consumed per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 5 (cadets).</i>				
ANIMAL FOOD.				
Meats, 158 grams.....	Grams. 32.3	Grams. 5.5	Grams.	Calories.
Fish, 60 grams.....	10.9	1.7		
Eggs, 12 grams.....	1.7	1.2		
Milk, 57 grams.....	2.3	2.1	2.7	
Fats, 14 grams.....		12.9		
Total animal food.....	47.2	23.4	2.7	
VEGETABLE FOOD.				
Cereals: Bread, 89 grams; rice, 542 grams.....	43.9	6.7	460.7	
Sugar, 74 grams.....			69.0	
Legumes and their preparations: Legumes, 25 grams; miso, 19 grams; shoyu, 51 grams.....	9.4	.5	18.2	
Vegetables, 307 grams.....	5.5	.9	36.0	
Total vegetable food.....	58.8	8.1	583.9	
Total food {Total nutrients.....	106.0	31.5	586.6	
{Digestible nutrients.....	92.2	26.8	574.9	3,072
<i>Study No. 6 (subofficers).</i>				
ANIMAL FOOD.				
Meats, 206 grams.....	42.1	7.2		
Fish, 83 grams.....	15.0	2.4		
Eggs, 10 grams.....	1.4	1.2		
Milk, 44 grams.....	1.8	1.6	2.1	
Fats, 23 grams.....	.1	20.5		
Total animal food.....	60.4	32.9	2.1	
VEGETABLE FOOD.				
Cereals: Bread, 221 grams; rice, 398 grams.....	44.8	7.3	415.1	
Sugar, 39 grams.....			37.5	
Legumes and their preparations: Legumes, 11 grams; miso, 18 grams; shoyu, 38 grams.....	5.6	.2	10.2	
Vegetables, 357 grams.....	6.4	1.1	41.9	
Total vegetable food.....	56.8	8.6	504.7	
Total food {Total nutrients.....	117.2	41.5	506.8	
{Digestible nutrients.....	102.0	35.3	496.7	2,867
<i>Study No. 7 (officers)</i>				
ANIMAL FOOD.				
Meats, 275 grams.....	56.4	9.6		
Fish, 121 grams.....	21.9	3.5		
Eggs, 24 grams.....	3.2	2.8		
Milk, 24 grams.....	.9	.9	1.1	
Fats, 36 grams.....	.1	33.2		
Total animal food.....	82.5	50.0	1.1	
VEGETABLE FOOD.				
Cereals: Bread, 145 grams; rice, 501 grams.....	45.9	7.2	457.8	
Sugar, 64 grams.....			61.4	
Legumes and their preparations: Legumes, 27 grams; miso, 16 grams; shoyu, 54 grams.....	9.8	.5	19.3	
Vegetables, 515 grams.....	9.2	1.5	60.3	
Total vegetable food.....	64.9	9.2	598.8	
Total food {Total nutrients.....	147.4	59.2	599.9	
{Digestible nutrients.....	128.2	50.3	587.9	3,508

During the voyage there were many cases of sickness from different diseases, but the large majority of the cases were those afflicted with kakke, or beriberi. Five of the officers and subofficers, 4 of the cadets,

and 164 of the marines suffered from this disease, and 25 of the marines died. Soon after the return of the battle ship, a special committee was appointed to study the conditions (see p. 13). The results of the dietary studies were included in their report.

In examining the statistics obtained during this voyage it was seen that the largest proportion of the kakke patients were among the marines, whose ration contained the smallest amount of protein and the widest nutritive ratio. The facts revealed in this case, together with the experience of preceding years, established a firm conviction of the necessity of increasing the amount of protein in the ration as a preventive against kakke. It was the opinion of the committee that to nourish the marines better and on a higher nitrogen level was indispensable to keeping them in a healthy condition and free from the disease, and that the increased expense necessary to provide the better ration would be entirely repaid by an increased capacity for work and by the saving of the expense of caring for the sick. That this view was justified was proved by subsequent investigations in the navy.

The outcome of this investigation was the navy food supply act of 1884. The ration per man per day provided in accordance with this act consisted of 300 grams of meat, 150 grams of fish, 45 grams of milk, 15 grams of fat, 675 grams of rice or its equivalent in bread, 75 grams of sugar, 45 grams legumes, 52 grams miso, 60 grams of shoyu, and 450 grams of vegetables, besides condiments. This ration was sufficient to furnish about 195 grams of protein, 45 grams of fat and 770 grams of carbohydrates, with a fuel value of 4,295 calories per man per day.

With the specific purpose of testing the effect of the improved ration upon the health of the marines, the battle ship *Chikuba* was ordered to make a voyage over exactly the same route as that followed by the *Ryujō*. The *Chikuba* left Japan on February 3, 1884, and returned on November 16 of the same year after an absence of 287 days. On board the battle ship were 35 officers, 25 naval cadets, and 297 marines. The number of kakke patients during this voyage was 14, namely, 2 cadets and 12 marines. The results were considered most satisfactory.

DIETARY STUDY WITH MILITARY CADETS (No. 8).

This study was made by Eijkmann^a with military cadets in Rikugun Shikwangakko (Army School for Noncommissioned Officers), Tokyo, during several nonconsecutive days in September and October, 1882. Neither the ages nor the weights of the cadets were given in the original report, but the cadets were said to be still in the growing period at the time the study was made.

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1886, No. 1, p. 82.

The cooked food was weighed at each meal. Rice was the principal food material. The amount eaten per man was weighed for 10 different meals and found to average 584 grams per meal, or 1,750 grams per day. The amount of water in cooked rice was determined eleven times and found to average 63.2 per cent. As supplemental food, beef or fish was used regularly. Miso, shoyu, and tofu, edible burdock root, carrots, onion, radish, taro, and other green vegetables were also constituents of the diet. The total quantity of supplemental food per man was weighed at 18 different meals and found to average 757 grams per man per day, the average water content being 85.8 per cent. A composite sample of the cooked rice eaten and one of the supplemental food were obtained and analyzed. The results of the analyses are given in Table 6.

TABLE 11.—*Results of dietary study No. 8.*

Kinds and amounts of food consumed per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
	Grams.	Grams.	Grams.	Calories.
Rice, cooked, 1,750 grams (136)	48.3	2.1	589.9	.....
Supplemental food, 757 grams (137)	34.8	11.6	41.1	.....
Total food (Total nutrients)	83.1	13.7	631.0	.....
(Digestible nutrients)	72.3	11.7	618.1	3,021

The urine of three of the cadets was collected during four days subsequent to the study and was found to average per man per day 928 cubic centimeters, containing 11.4 grams of nitrogen.

DIETARY STUDIES WITH PRISONERS (Nos. 9-11).

These studies were made by J. F. Eijkmann,^a June 5-12, 1882, at Kajibashi Prison, Tokyo. The subjects were three classes of prisoners: (1) Prisoners without work, the average weight of 20 being 47.6 kilograms, ranging from 41.3 to 75.7 kilograms; (2) prisoners at light work, the average weight of 20 being 48 kilograms, ranging from 41.5 to 58 kilograms; and (3) prisoners at hard work, the average weight not given. The total number of prisoners in each study was not recorded in the original report. The statistics reported simply showed the quantities of total food and of nutrients consumed per man per day by each class.

The cooked food used at each meal was weighed. The principal food consisted of a rice-barley mixture (1 pint of rice to 1.5 pints of barley, cooked together). The quantity of this mixture eaten varied with the different classes. The supplemental food consisted of miso soup and pickled radish for breakfast, and miso, beans, burdock root, konnyaku, dried algæ, radish, taro stems, and pickled radish for

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1886, No. 1, p. 67.

dinner and supper. The average quantity of supplemental food per man was the same for each class.

A composite sample of the rice-barley mixture and another of the supplemental food were obtained for analysis, the quantity of each kind of food equal to that served to one person being reserved for this composite sample. In addition to the complete analyses of these samples the water content of the rice-barley was determined each day and found to average 66 per cent, which figure was used in computing the percentage composition of the material.

The data regarding amounts of food consumed and nutrients supplied are given in the following table:

TABLE 12.—*Results of dietary studies Nos. 9-11.*

Study No.	Class of prisoners.	Kinds and amounts of food consumed per man per day.	Nutrients and energy per man per day.			
			Protein.	Fat.	Carbohydrates.	Fuel value.
9	Prisoners without work.	Rice-barley, cooked, 1,141 grams (138)...	Grams. 35.6	Grams. 3.3	Grams. 344.2	Calories.
		Supplemental food, 340 grams (139)....	12.2	3.5	27.3	.....
		Total food (Total nutrients.....)	47.8	6.8	371.5	.....
		(Digestible nutrients....)	36.3	5.6	360.4	1,726
10	Prisoners at light work.	Rice-barley, cooked, 1,426 grams (138) .	44.5	4.1	430.3	.....
		Supplemental food, 340 grams (139)....	12.2	3.5	27.3	.....
		Total food (Total nutrients.....)	56.7	7.6	457.6	.....
		(Digestible nutrients....)	43.1	6.2	443.9	2,112
11	Prisoners at hard work.	Rice-barley, cooked, 1,996 grams (138) .	62.4	5.7	602.4	.....
		Supplemental food, 340 grams (139)....	12.2	3.5	27.3	.....
		Total food (Total nutrients.....)	74.6	9.2	629.7	.....
		(Digestible nutrients....)	56.7	7.5	610.8	2,884

The urine of three prisoners in each class was collected during eight days following the study. The amounts of urea were determined and the nitrogen calculated from the data thus obtained. The average values for prisoners without work were 13.5 grams urea, equivalent to 6.3 grams nitrogen; for prisoners at light work, 14 grams urea, equivalent to 6.5 grams nitrogen; and for prisoners at hard work, 16.4 grams urea, equivalent to 7.7 grams nitrogen.

DIETARY STUDIES WITH STUDENTS AND BUSINESS CLERKS (Nos. 12-15).

These studies were made by R. Tahara^a and his associates, in connection with investigations of the chemical analyses of Japanese food materials at the Sanitary Laboratory, Tokyo. K. Suda, a chemist in the laboratory, collected the data regarding the food consumed in each study, by weighing all the food materials used in

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1887, No. 2, p. 1.

the kitchen in preparation of each meal. The number of persons present at each meal was also noted. The statistics given in the original report show the amounts of food consumed and nutrients supplied per person per meal. The average amount of each kind of food per man per meal was obtained by dividing the total weight of the food by the total number of persons at the meal, without any considerations of the differences in ages of the persons present. The quantities of nutrients in the various materials consumed were calculated by use of results of analyses previously made in the laboratory. (See Table 5.) No statement regarding waste was found in the original report.

In calculating the amounts of nutrients in the food consumed, the investigators took no account of the shoyu eaten. Since a considerable amount of this material was used in each study, it seemed desirable to the compiler to compute the quantities of nutrients in it. In study No. 13, the nutrients in dried radish were also included by the compiler. The values used in these computations were: For shoyu, protein 8.44 per cent, carbohydrates 5.10 per cent; for dried radish, protein 9.29 per cent, fat 0.12 per cent and carbohydrates 46.90 per cent.

Dietary study No. 12.—This study was made with students in a dormitory of the higher normal school at Tokyo, a Government institution. It began May 7, 1886, and continued ten days. There were 130 students, from 17 to 25 years of age, the majority being about 20 years old. Their average weight was 53.4 kilograms, the range being from 45.1 to 62 kilograms.

The diet consisted of both animal and vegetable foods, beef, fish, and eggs being used regularly. The price of board was 3.50 yen (\$1.75) per man per month.

It was stated that since the introduction of gymnastics, including military drill, into the school, the food consumption by the students had noticeably increased.

Dietary study No. 13.—This study was made with pupils in "Kogyoku-Sha," a private school in Tokyo. The study began May 19, 1886, and continued seven days.

The pupils in this school consisted of 21 boys 11 to 14 years old, with an average weight of 32.2 kilograms, and 48 boys 15 to 21 years old (the majority below 20 years), with an average weight of 48.3 kilograms. The diet consisted chiefly of vegetable foods. Beef and eggs were used only twice during the week, but fish was used oftener. The cost of board per person was 2 yen (\$1) a month.

The amounts of nutrients and energy as given in the table are per person per day. In the original report no account was taken of the differences in the ages and weights of the subjects. Assuming that the 21 boys averaging 32.2 kilograms would consume as much food as

$(21 \times 32.2 \div 48.3 =)$ 14 of the older and heavier pupils, the total number would be equivalent to $(14 + 48)$ 62 of the latter, and the corresponding amounts of nutrients and energy per man per day would be as follows: Protein, 90.5 grams; fat, 14.1 grams; carbohydrates, 525 grams; fuel value, 2,620 calories. These figures would perhaps represent more fairly than those in the original report the amounts of nutrients per day on the basis of an adult. However, no data were given regarding the amounts of waste in the study, which may have been sufficient to counterbalance the effect of neglecting the weight of the smaller boys.

Dietary study No. 14.—This study was made with pupils at "Nisho Gakusha," a private school in Tokyo. The study began June 21, 1886, and continued seven days. The number of pupils participating in the meals was from 59 to 66 per day. Their ages ranged from 14 to 24 years, and their average weight was 48.4 kilograms. The diet consisted principally of vegetable foods. Small amounts of animal food, including beef, fish, and eggs were eaten, but these materials were not used regularly. The cost of board was 2 yen (\$1) per month.

Unfortunately the data do not show how many of the pupils were young and still growing. Some of the subjects at least were in this condition, and the results of the study may therefore not fairly represent the food consumption for an adult under the same circumstances.

Dietary study No. 15.—This study was made with employees (clerks) in the retail store "Echigoya," in Tokyo. The study began July 5, 1886, and continued seven days. The number of employees who were present on the different days varied from 72 to 85. Among them were 21 clerks from 11 to 16 years old, and averaging 32.9 kilograms in weight. The remainder of the employees were from 17 to 50 years old, and averaged 51.8 kilograms in weight. The diet consisted very largely of vegetable foods. Fish was used only twice during the study and the amount was small. This diet may very probably be considered as fairly representative of that of Japanese in similar circumstances.

The amounts of food and nutrients were given in the original report per person per meal. The number of persons at each meal was not stated. In calculating the results of the study the investigator made no allowance for the younger age and smaller size of the 21 boys. These would be on the average about equivalent to 13 men at the average weight of those included in the study. Since the data do not indicate the definite numbers and ages of the persons at each meal, it is impossible to make an accurate estimate of the results on the basis of an adult, but probably the corresponding amounts of nutrients and energy per man per day would be, roughly, 12 to 15 per cent larger than those given in Table 13.

TABLE 13.—Results of dietary studies Nos. 12–15.

Kinds and amounts of food consumed per person for 10 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 12.</i>				
ANIMAL FOOD.				
Meats: Beef, 851 grams; beef tongue, 42 grams; beef fat, 90 grams.....	Grams. 17.6	Grams. 15.3	Grams. 0.4	Calories.
Fish: Bonito, dried, 48 grams; fish (<i>Hyporhamphus sajori</i>), 115 grams; yellow tail, 77 grams; mullet, 16 grams; halibut, 109 grams; horse mackerel, 93 grams; tunny, 480 grams.....	20.8 2.6	4.3 2.5	1	.....
Eggs, 207 grams.....	.....	.....	.....	.....
Total animal food.....	41.0	22.1	.5	.....
VEGETABLE FOOD.				
Cereals: Rice, 7,647 grams; wheat flour, 28 grams; fresh fu, 10 grams.....	53.9	3.1	580.4 15.7	.....
Sugar, 177 grams.....	.....	.....	.....	.....
Legumes and their preparations: Miso, 651 grams; shoyu, 538 grams; ^a tofu, 187 grams; fried tofu, 21 grams; broiled tofu, 58 grams; dried tofu, 5 grams.....	15.4	5.1	13.1	.....
Vegetables: Algae— <i>Uloperyx pinnatifida</i> , 15 grams; <i>Laminaria</i> sp., 15 grams; burdock, 42 grams; carrots, 90 grams; arrowhead, 137 grams; dried fungus (<i>Agaricus shiitake</i>), 5 grams; greens, 223 grams; greens, pickled, 612 grams; konnyaku, 57 grams; dried konnyaku, 5 grams; lotus rhizome, 362 grams; nori, 1 gram; onions, 728 grams; potatoes, 169 grams; radishes, 446 grams; sesame seeds, 6 grams; bamboo shoot, 42 grams; <i>Aralia cordata</i> shoot, 45 grams; spinach, 49 grams; radishes, pickled, 1,261 grams.....	8.1	1.1	28.1	.....
Total vegetable food.....	77.4	9.3	637.3	.....
Total food/Total nutrients.....	118.4	31.4	637.8	.....
Digestible nutrients.....	103.0	26.7	625.0	3,329
Condiments: Table salt, 13 grams; dried ginger, 11 grams; poppy seed, 1 gram; pepper, horse radish, and vinegar.	.....	.....	.....	.....
<i>Study No. 13.</i>				
ANIMAL FOOD.				
Meats: Beef, 87 grams.....	2.5	1.0	.....	.....
Fish: Dried bonito, 7 grams; fish (<i>Hyporhamphus sajori</i>), 57 grams; poulpe, 70 grams; hampen, 40 grams; kamaboko, 46 grams; dried calamary, 8 grams; horse mackerel, 99 grams; yellow tail, 112 grams.....	14.8 2.4	.5 2.3	.7 .1	.....
Eggs, 132 grams.....	.....	.....	.....	.....
Total animal food.....	19.7	3.8	.8	.....
VEGETABLE FOOD.				
Rice, 4,051 grams.....	40.9	2.3	437.4 9.3	.....
Sugar, 76 grams.....	.....	.....	.....	.....
Legumes and their preparations: Soy beans, 41 grams; string beans, 105 grams; miso, 301 grams; shoyu, 223 grams; ^b tofu, 154 grams; fried tofu, 35 grams.....	13.5	5.2	10.1	.....
Vegetables: Algae— <i>Ecklonia bicyclis</i> , 5 grams; <i>Laminaria</i> sp., 3 grams; <i>Uloperyx pinnatifida</i> , 5 grams; arrowhead, 22 grams; burdock, 145 grams; dried gourd, 13 grams; greens, 363 grams; greens, pickled, 886 grams; konnyaku, 157 grams; lily bulb, 26 grams; onions, 24 grams; <i>Petasites japonicus</i> , 53 grams; radishes, 137 grams; dried radishes, 16 grams; ^a bamboo shoot, 90 grams; radishes, pickled, 104 grams.....	7.2	1.4	14.1	.....
Total vegetable food.....	61.6	8.9	470.9	.....
Total food/Total nutrients.....	81.3	12.7	471.7	.....
Digestible nutrients.....	70.7	10.8	462.3	2,354
Condiments, etc.: Vinegar, 39 grams; dried plums, pickled; table salt; ginger.	.....	.....	.....	.....

^a Shoyu was not taken into account in the original. Including the nutrients of shoyu causes an increase of 3.5 grams protein and 2.8 grams carbohydrates per man per day over the results given by the investigators.

^b Shoyu and dried radish were not taken into account in the original report. Including the nutrients of these materials causes an increase of 2.6 grams of protein and 1.6 grams of carbohydrates per person per day over the results given by the investigators.

TABLE 13.—Results of dietary studies Nos. 12-15—Continued.

Kinds and amounts of food consumed per person for 10 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
Study No. 14.				
ANIMAL FOOD.				
Meats: Beef, 47 grams.....	Grams. 1.3	Grams. .5	Grams.	Calories.
Fish: Bonito, 123 grams; dried bonito, 11 grams; <i>Parastipoma japonicum</i> , 68 grams; <i>Scomberomorus sinensis</i> , 60 grams; ear shell, 61 grams.....	11.0	.6	.....	.....
Eggs, 28 grams.....	.5	.5	.....	.....
Total animal food.....	12.8	1.6	.....	.....
VEGETABLE FOOD.				
Cereals: Rice, 3,797 grams; fu, 11 grams.....	38.7	2.2	410.9	.....
Sugar and starch: Sugar, 62 grams; starch, 2 grams.....	.....	.....	8.0	.....
Legumes and their preparations: Soy beans, 29 grams; string beans, 35 grams; miso, 409 grams; shoyu, 603 grams; ^a tofu, 292 grams; broiled tofu, 62 grams.....	20.7	5.9	16.1	.....
Vegetables: Algae— <i>Uloperyx pinnatifida</i> , 7 grams; <i>Chrysanthemum coronarium</i> , 76 grams; eggplant, 48 grams; dried konnyaku, 1 gram; lotus rhizome, 33 grams; nori, 6 grams; onions, 215 grams; <i>Petasites japonicus</i> , 65 grams; potatoes, 187 grams; radishes, 77 grams; dried radishes, 143 grams; radishes, pickled, 616 grams; sesame seeds, 3 grams; bamboo shoot, 44 grams; taro root, 104 grams.....	4.3	.4	19.0	.....
Total vegetable food.....	63.7	8.5	454.0	.....
Total food { Total nutrients.....	76.5	10.1	454.0	.....
{ Digestible nutrients.....	66.6	8.6	444.9	2,242
Condiments: Vinegar, 10 grams; <i>Perilla arguta</i> seeds.....	.....	.....	.....	.....
Study No. 15.				
ANIMAL FOOD.				
Fish: Horse mackerel, 107 grams; <i>Scomberomorus sinensis</i> , 118 grams; dried bonito, 11 grams.....	7.7	.5	.....	.....
VEGETABLE FOOD.				
Cereals: Rice, 3,382 grams.....	33.8	1.9	365.3	.....
Sugar, 50 grams.....	.....	.....	6.3	.....
Legumes and their preparations: Beans, 58 grams; broad beans, 73 grams; soy beans, 53 grams; string beans (green), 152 grams; miso, 141 grams; shoyu, 150 grams; ^b tofu, 125 grams.....	13.0	3.5	17.1	.....
Vegetables: Algae— <i>Uloperyx pinnatifida</i> , 6 grams; eggplant, 170 grams; fern (<i>Osmunda regalis</i>), 35 grams; greens, 37 grams; dried konnyaku, 2 grams; melons, 19 grams; squash, 46 grams; radishes, pickled, 315 grams.....	2.2	.1	6.6	.....
Total vegetable food.....	49.0	5.5	395.3	.....
Total food { Total nutrients.....	56.7	6.0	395.3	.....
{ Digestible nutrients.....	49.3	5.1	387.4	1,892
Beverages and condiments: Dried ginger, sake, sweet sake, little (quantity not given).	.....	.....	.....	.....

^a Shoyu was not taken into account in the original. Including the nutrients of shoyu causes an increase of 7.3 grams protein and 4.4 grams carbohydrates per person per day over the results given in the original report.

^b Including the nutrients of shoyu increases the protein 1.9 grams and carbohydrates 1.2 grams per person per day over the results given in the original report.

DIETARY STUDIES WITH PROFESSIONAL MEN (Nos. 16 and 17.)

The results of these two studies were cited by Tahara ^a with very little detail. One study (No. 16) is the result of observations made by Prof. K. Osawa, a physiologist of Tokyo, upon his own diet during a period of seventeen days, from June 14 to July 6, 1883. He weighed 45 kilograms. His diet consisted of both animal and vegetable food, 56.7 per cent of the total protein being supplied by animal foods, 23.3 per cent by rice, and the remaining 20 per cent by other vegetable foods. The other study (No. 17) was made by K. Suchi, a chemist employed in the Sanitary Laboratory, Tokyo, upon his own diet. Neither the age nor weight of the subject nor the date nor duration of the study was mentioned. In the diet 52.7 per cent of the total protein was supplied by animal food, 45.2 per cent by rice, and the remaining 2.1 per cent by other vegetable foods.

TABLE 14.—Results of dietary studies Nos. 16 and 17.

Study No.	Kind of food.	Nutrients and energy per man per day.					
		Total.			Digestible.		
		Protein.	Fat.	Carbo-hydrates.	Protein.	Fat.	Fuel value.
16	Mixed diet.....	Grams. 86.0	Grams. 26.0	Grams. 226.0	Grams. 74.8	Grams. 22.1	Grams. 222.5
17	Mixed diet.....	83.5	21.8	352.1	72.7	18.5	345.5
							Calories. 1,480
							1,940

DIETARY STUDY WITH MARINES (No. 18).

This study was made at Yokosuka, by K. Ishihara, ^b a navy surgeon, during the whole month of October, 1887. The subjects were marines garrisoned at Yokohama. The number of persons included in the study was not stated in the original report.

The diet consisted of both animal and vegetable foods. The weights of animal foods given in Table 15 refer to edible portion only. In estimating the amount of edible material from the amount purchased, 40 per cent of the poultry, 33 per cent of the fish, and 10 per cent of the eggs was considered as refuse (bone, shell, etc.). Bread was the most important of the cereal foods used; it furnished 45 per cent of the total protein and 65 per cent of the total carbohydrates of the diet, whereas rice supplied only 5 per cent of the total protein and 17 per cent of the total carbohydrates.

No details of the method of the study were given in the report. Although it is not known exactly, it is probably safe to infer that the amounts of food and nutrients in this study included a little waste.

^a Eisei Shiken Iho (Bul. Imp. Sanit. Lab.), Tokyo, 1887, No. 2, Appendix table.

^b Kaigun Iji Hokoku Saiyo (Rpt. Med. Bur. Imp. Navy), Tokyo, 1887, No. 11, p. 63.

TABLE 15.—Data of dietary study No. 18.

Kinds and amounts ^a of food consumed per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats: Beef, 240 grams; poultry, 24 grams.....	41.0	21.1		
Fish: Mackerel, 3 grams; dried bonito, 0.5 gram.....	1.0	.2		
Eggs: 47 grams.....	6.3	5.4		
Milk: Condensed milk, 33 grams.....	2.7	3.1	15.9	
Butter: Butter, 13 grams; fats, 2 grams.....		14.2		
Total animal food.....	51.0	44.0	15.9	
<i>Vegetable food.</i>				
Cereals: Bread, 694 grams; rice, 109 grams; wheat flour, 15 grams; fu, roasted, 1 gram; vermicelli, 3 grams.....	63.2	11.6	445.3 ^b 1.0?	
Sugar and starch: Sugar, 10.7 grams; starch, 0.2 gram.....				
Legumes and their preparations: Miso, 16 grams; shoyu, 9 grams; tofu, 57 grams.....	6.3	2.6	3.6	
Vegetables: Cabbage, 20 grams; carrots, 9 grams; potatoes, 98 grams; onions, 85 grams; radishes, 110 grams; squash, 27 grams.....	3.6	.3	56.9	
Total vegetable food.....	73.1	14.5	506.8	
Total food.....	124.1	58.5	522.7	
Total nutrients.....	108.0	49.7	512.2	3,095
Condiments: Barley, roasted, 0.2 gram; tea, 0.7 gram; table salt, 7.5 grams.....				

^a In the original the weights were given in ounces in apothecary weight. In calculating to grams, 1 ounce was taken as equivalent to 32 grams, following the original investigator.

^b The ? was in the original report. Carbohydrates in 10.7 grams of sugar was given as 0.9 gram. Evidently there was an error in the decimal point, either in the amount of sugar used or in its calculated carbohydrates.

DIETARY STUDIES WITH PEOPLE REPRESENTING DIFFERENT CLASSES (Nos. 19-21).

O. Kellner and Y. Mori,^a at the Agricultural Chemical Laboratory at Komaba, near Tokyo, made an investigation of the nutritive value of the vegetable and mixed diets which they considered representative of those of people in three different classes in Japan. The purpose of the investigation was threefold—namely, determinations of (1) the amounts of nutrients supplied by different diets, (2) the digestibility of the nutrients, and (3) the metabolism of nitrogen by the subject on the different diets. The data regarding the food consumed and nutrients supplied are here summarized as dietary studies; the data regarding the digestion and nitrogen metabolism experiments are given later (pp. 151 and 213).

The studies of food consumed were more in the nature of dietary experiments than of ordinary dietary studies, since the kind of food in each experiment was prescribed. However, the diet in each case was decided upon after consideration of data obtained from different parts of the country regarding the dietary habits of the different classes, and the amounts eaten were regulated by the desires and

^a Mitt. Deut. Gesell. Natur- u. Völkerk. Ostasiens, 4 (1887), No. 37, p. 305; Ztschr. Biol., 25 (1889), p. 102; Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), p. 148; Dai Nippon Shiritsu Eiseikwai Zasshi (Jour. Sanit. Soc. Japan), Tokyo, 1888, No. 55, p. 4.

capacity of the subject; hence it seems proper to consider the data of food consumption here given in comparison with regular dietary studies.

The subject of each study was Y. Mori, one of the investigators, an assistant at the laboratory, 23 years old, and weighing 52 kilograms. Each study continued six days, during the last three of which the digestibility of the diet was determined.

In study No. 19 the diet consisting of beef, milk, rice and vegetables was supposed to represent that of well-to-do classes in larger cities where the dietary habits of the natives have been more or less influenced by those of foreigners residing there. In study No. 20 the diet of fish, rice, and vegetables was assumed to be typical of that of the population of the coast regions, and of the middle classes in general. In study No. 21 the diet consisting of rice, barley, and vegetables (the rice-barley mixture being composed of 2 parts of rice and 3 parts of barley, which is a very common proportion) was supposed to represent that of the rural population of the interior of the country. A preliminary test with the latter diet indicated that the subject could not take larger amounts of the foods mentioned than those given in Table 16, without disturbing his digestive functions. It is believed, however, that the people among whom such a diet prevails eat much larger quantities than those consumed by the subject of this experiment. It is a general custom among the rural population to take four or even five meals a day.

The foods used in each study were weighed after cooking. The rice and the rice-barley mixture were cooked in water, whereas the remaining food materials were cooked with shoyu. In each case a composite sample of the food was obtained for analysis, the percentage composition of the composites being given in Table 6. Nitrogen was determined by the Kjeldahl method; proteid nitrogen was determined after precipitation with copper hydroxid. Crude fiber was determined by the Stohmann-Henneberg method. Fat was determined by extracting with ether. Water and ash were determined in the usual manner, and carbohydrates estimated by difference.

TABLE. 16.—*Results of dietary studies Nos. 19-21.*

Kinds and amounts of food consumed per person per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 19.</i>				
ANIMAL FOOD.	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats: Beef, cooked, 250 grams				
Milk, 200 cubic centimeters				
VEGETABLE FOOD.				
Cereals: Rice, cooked, 1,000 grams				
Vegetables: Greens, cooked, 50 grams; potatoes, cooked, 150 grams; radishes, pickled, 50 grams				
Total food (130)	123.0	20.7	415.7	
{ Total nutrients	111.0	17.6	412.8	
{ Digestible nutrients				2,388
Beverage: Tea decoction, 300 cubic centimeters.				

^a See page 152.

TABLE 16.—Results of dietary studies Nos. 19-21—Continued.

Kinds and amounts of food consumed per person per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 20.</i>				
ANIMAL FOOD.				
Fish: Tunny, cooked, 150 grams.....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
VEGETABLE FOOD.				
Cereals: Rice, cooked, 1,200 grams.....				
Legumes, etc.: Tofu, cooked, 150 grams.....				
Vegetables: Potatoes, cooked, 200 grams; radishes, pickled, 100 grams.....				
Total food (129) { Total nutrients..... Digestible nutrients.....	109.3 α 95.4	19.4 16.5	465.8 α 463.9	2,528
Beverage: Tea decoction, 300 cubic centimeters.				
<i>Study No. 21.</i>				
VEGETABLE FOOD.				
Cereals: Rice (2 parts) and barley (3 parts), cooked together, 1,200 grams.....				
Vegetables: Greens, cooked, 150 grams; potatoes, cooked, 300 grams; dried radishes, cooked, 400 grams; radishes, pickled, 100 grams.....				
Total food (128) { Total nutrients..... Digestible nutrients.....	70.9 α 53.7	11.6 9.5	413.5 α 399.4	2,002
Beverage: Tea decoction, 300 cubic centimeters.				

^a See page 152.

The investigators pointed out the need of improving the vegetable diet of the rural population by the use of foods rich in protein, such as fish and legumes. In the time covered by the test the subject was unable to establish nitrogen equilibrium with the diet followed in study No. 21, and in view of this fact they considered such a diet as insufficient for a man from which work is expected, because of the small amount of protein furnished. However, in the light of later investigations (see p. 105), it would appear that the failure to establish nitrogen equilibrium in this particular case may have been due not so much to the insufficiency of protein as to the small amount of energy furnished by the diet. A considerable amount of experimenting and discussion on this particular topic followed these studies.

DIETARY STUDY WITH A SCHOOL BUSINESS AGENT (No. 22).

This study was made by J. Tsuboi,^a of the Hygienic Institute of the University of Tokyo. It continued ten days, from February 27 to March 7, 1888 (?).

The subject, K. S., was a business agent in a public school in Tokyo. He was 49 years old and weighed 57.7 kilograms. During the period of the investigation he was occupied chiefly with his duties at the school, from 8 or 9 a. m. to 3.30 p. m. each day. The school was

^aTokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), p. 731.

situated about 2.5 miles from his residence, and he always walked there and back. On one of the experimental days (March 4) he walked a long distance (but how far is not stated) with a party that went to gather plum blossoms.

The diet consisted of animal and vegetable foods, meat or fish being used regularly. In the opinion of the investigator this diet may be considered as representative of people of the middle classes in Japan. The cooked food used was weighed by the subject himself at each meal. The proportion of water was determined in mochi and in broiled tofu, and the nutrients in these materials were computed by use of average figures for composition of water-free material. Water and nitrogen were determined in the buckwheat preparation, soba. These analytical data are given in Table 6.

TABLE 17.—Results of dietary study No. 22.

Kinds and amounts of food per man for 10 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
Meats: Chicken, 158 grams.....	Grams. 3.0	Grams. 0.8	Grams. 0.2	Calories.
Fish: Bonito, 56 grams; cod, 75 grams; eel, broiled, 60 grams; mackerel, salted, 79 grams; salmon, salted, 100 grams; tunny, 390 grams; oysters, 199 grams.....	15.9 2.3	5.6 2.3	1	..... .....
Eggs: Raw, 143 grams; fried, 45 grams.....	.....	.....	.....	.....
Total animal food.....	21.2	8.7	.3	.....
<i>Vegetable food.</i>				
Cereals: Rice, cooked, 11,890 grams; mochi (63), 675 grams; soba (57), 2,085 grams.....	40.6	2.5	480.0	.....
Legumes and their preparations: Beans, 173 grams; miso, 37 grams; miso soup, 2,145 grams; tofu, 206 grams; tofu, broiled (88), 109 grams; shoyu, 45 grams; soba sauce ^a , 375 grams.....	11.3	1.2	17.6	.....
Vegetables: Algae— <i>Ulopteryx pinnatifida</i> , 49 grams; <i>Aralia</i> <i>cordata</i> , 64 grams; arrowhead, 34 grams; burdock, 56 grams; greens, 270 grams; onions, 135 grams; peanuts, 15 grams; radishes, 19 grams.....	2.0	.9	6.0	.....
Total vegetable food.....	53.9	4.6	503.6	.....
Total food { Total nutrients	75.1	13.3	503.9	.....
{ Digestible nutrients	65.3	11.3	493.8	2,467

^aSoba sauce was classified under animal food in the original, though its composition was apparently assumed to be the same as that of shoyu. As there was no special reason to classify it under animal food, it was transferred to legumes and their preparations in this table.

Urine was collected during the first three and the last three days of the study, and the nitrogen in it was determined. During the first three days the subject eliminated 3,000 cubic centimeters of urine containing 29.08 grams nitrogen, and during the last three days 3,185 cubic centimeters of urine containing 30.45 grams of nitrogen. This would give a daily average of 1,008 cubic centimeters of urine containing 9.92 grams of nitrogen, corresponding to 62 grams of protein.

DIETARY STUDY WITH A PHYSICIAN (No. 23).

This study was made by J. Tsuboi^a for two days, beginning January 13, 1888 (?). The subject, R. U., was a physician in Tokyo, 24 years old. He lived at a boarding house, and paid 3.5 yen (\$1.75) per month for board.

The cooked food used was weighed at each meal by the subject himself, and the amounts of nutrients were computed by the investigator by use of average figures for percentage composition of Japanese food materials. The amount of water was determined in samples of the cooked calamary and cooked beans, and the nutrients of these materials were computed from the composition of the water-free substances.

The animal food used in this dietary consisted entirely of fish and furnished 14.5 per cent of the total protein, whereas legumes furnished 16.6 per cent. Rice was the chief article of food as the source of both protein and carbohydrates, furnishing 54.4 per cent of the former and 93.4 per cent of the latter. The urine collected during the first day of the study amounted to 1,300 cubic centimeters, containing 10.17 grams of nitrogen, or equivalent to 63.6 grams of protein.

TABLE 18.—Results of dietary study No. 23.

Kinds and amounts of food per person for 2 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
Fish: Calamary, cooked (31), 98 grams; crucian carp, 11 grams.....	Grams. 10.3	Grams. 0.4	Grams.	Calories.
<i>Vegetable food.</i>				
Cereal: Cooked rice, 2,783 grams.....	38.7	2.2	446.3	.....
Legumes, etc.: Beans, cooked (75), 34 grams; miso soup, 314 grams; fried tofu, 49 grams.....	11.8	6.3	11.7	.....
Vegetables: Carrots, cooked, 105 grams; greens, pickled, 90 grams; konnyaku, cooked, 120 grams; lotus rhizome, cooked, 26 grams; mixed vegetable dish, 71 grams; radish, 102 grams; radish, dried, 19 grams; radish, pickled, 52 grams; taro root, cooked, 68 grams.....	10.4	.5	20.1	.....
Total vegetable food.....	60.9	9.0	478.1	.....
Total food (Total nutrients.....)	71.2	9.4	478.1	.....
(Digestible nutrients.....)	61.9	8.0	468.5	231.5
Condiment: Vinegar, 210 grams.				

DIETARY STUDY WITH A MERCHANT (No. 24).

This study^b began March 13, 1888 (?), and continued ten days. The subject, R. F., was a pawnbroker of the well-to-do class in Tokyo. He was 28 years old, and weighed 47.6 kilograms at the beginning of the study. He was not very strong physically, though he had never

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), p. 613.

^b Ibid., p. 901.

had a serious illness. He was accustomed to walk a distance of about 2 miles each morning. Throughout the study he felt as well as usual except in the evening of March 22 and the early morning of March 23, when he had a slight diarrhea.

The subject was specially requested to eat the same kinds and amounts of food as usual during the study. The diet contained relatively large amounts of animal food, 61 per cent of the total protein being obtained from this source; 39.2 per cent of the total protein was derived from fish. Legumes formed a relatively unimportant part of this diet, supplying only 3.4 per cent of the total protein. The quantity of bread used was nearly as large as that of rice, and the former supplied 17.6 per cent of the total protein and 34.6 per cent of the total carbohydrates, whereas the latter furnished, respectively, 14.8 and 42.4 per cent.

Urine was collected in 24-hour periods during the first and last three days of the study. During the first three days the subject eliminated 2,600 cubic centimeters of urine, containing 38.94 grams of nitrogen, and during the last three days 3,450 cubic centimeters, containing 38.72 grams of nitrogen. This would give a daily average of 1,008 cubic centimeters of urine, containing 12.94 grams of nitrogen, corresponding to 80.9 grams of protein.

TABLE 19.—Data of dietary study No. 24.

Kinds and amounts of food per person for 10 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
	Grams.	Grams.	Grams.	Calories.
Meats: Beef, 461 grams.....	9.6	2.4	0.2	.....
Fish: Angel fish, 236 grams; bonito, 53 grams; dried bonito, 18 grams; <i>Konosirus punctatus</i> , 112 grams; dab, 158 grams; eel, broiled, 191 grams; halibut, 233 grams; mullet, 169 grams; oysters, 555 grams; young sardine, dried, 45 grams; shark, 64 grams; tunny, 367 grams.....	36.8	7.1	.....	.....
Eggs, 326 grams.....	4.1	3.9	.2	.....
Milk, 1,800 cubic centimeters.....	6.6	7.2	9.3	.....
Total animal food.....	57.1	20.6	9.7	.....
<i>Vegetable food.</i>				
Cereals: Bread, 2,366 grams; cooked rice, 4,950 grams.....	30.2	1.1	287.6	.....
Sugar, etc.: Sugar, 120 grams; plum jam, 191 grams; strawberry jam, 218 grams.....	.....	.....	41.0	.....
Legumes, etc.: Shoyu, 289 grams; tofu, 360 grams.....	3.2	1.1	4.3	.....
Vegetables: <i>Aralia cordata</i> , 30 grams; ginger, pickled, 108 grams; greens, 330 grams; greens, pickled, 105 grams; horse-radish, 13 grams; orange, 913 grams; radish, salted, 199 grams; radish, pickled, 15 grams; sweet potatoes, 461 grams.....	2.8	.3	26.3	.....
Total vegetable food.....	36.2	2.5	359.2	.....
Beverages: Beer, 878 grams; sake, ^a 56 grams.....	0.4	.....	4.8	.....
Total food { Total nutrients.....	93.7	23.1	373.7	.....
{ Digestible nutrients.....	81.5	19.6	366.2	2,082
Condiments: Table salt, 11 grams; coffee, tea, and lemonade.....	.....	.....	.....	.....

^a Sake was assumed to contain 12.45 per cent alcohol (equivalent to 21.54 per cent of carbohydrates) and 0.76 carbohydrates; in total, 22.30 per cent of carbohydrates.

DIETARY STUDY WITH A MAN AT HARD LABOR (No. 25.)

This study was made by J. Tsuboi.^a It began on March 24, 1888 (?), and continued three days. The subject, S. S., 17 years old, was very strong, and weighed 50.7 kilograms. He was a total abstainer from alcoholic drinks and used tea in moderate quantities.

The subject was employed by one of the rice merchants in Tokyo and worked ten hours daily cleaning rice, which is considered very hard labor in Japan. The cleaning process consists in pounding the rice in a mortar by means of a wooden pestle attached to the end of a lever which is operated by the foot. The weight of the pestle and of the lever, and the distance between the pestle and the fulcrum of the lever, were such that the raising of the pestle in this case was calculated by the investigator to be equivalent to raising 45 kilograms. It was calculated that the pestle was raised 1,020 times per hour. The height to which the pestle was raised was not stated by the investigator, but was probably 1.5 feet. If this were done continuously for ten hours, the amount of work performed would be 1,514,700 foot-pounds. This is somewhat less than the average work of a man as shown by estimates summarized in a previous bulletin of this Office.^b

The subject lived on a mixed diet, and used fish regularly. The quantities of the nutrients in the food consumed were calculated by the use of average values for percentage composition of Japanese food materials, though hampen and fried vegetables were analyzed. Water was determined in dried mackerel and the amounts of nutrients in the fish eaten were computed from the water-free material.

The results of the study are given in the following table:

TABLE 20.—Results of dietary study No. 25.

Kinds and amounts of food per man 3 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
Fish: Mackerel, dried (23), 52.5 grams; yellow tail, 75 grams; shark, 83 grams; hampen (32), 101 grams.....	<i>Grams.</i> 21.2	<i>Grams.</i> 2.1	<i>Grams.</i> 4.5	<i>Calories.</i>
<i>Vegetable food.</i>				
Cereal: Rice, cooked, 7,290 grams.....	67.6	3.9	779.5	.....
Legumes and their preparations: Beans, 101 grams; miso soup, 855 grams.....	12.3	3.5	21.6	.....
Vegetables: Greens, pickled, 300 grams; miscellaneous vegetables, fried (120), 75 grams.....	2.3	11.6	2.7	.....
Total vegetable food.....	82.2	19.0	803.8	.....
Total food { Total nutrients	103.4	21.1	808.3	.....
{ Digestible nutrients	89.9	17.9	792.2	3,841

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 3 (1889), p. 31.

^b U. S. Dept. Agr., Office of Experiment Stations Bul. 98, p. 66.

In this dietary, fish furnished 20.5 per cent and legumes 11.9 per cent of the total protein; rice furnished 65.3 per cent of the total protein and 96.4 per cent of the total carbohydrates. Unfortunately, the duration of the study was short, and the subject was not in his usual condition during the last day of the study, and ate much less than on the other days. On this day he took only 2,180 grams total food, including 1,660 grams cooked rice, whereas on previous days he ate 3,210 to 3,540 grams total food, which included 2,655 to 2,970 grams of cooked rice. Calculating the amounts of nutrients for each day separately the results would be as follows:

TABLE 21.—*Nutrients and energy in diet on different days (dietary, No. 25).*

Date.	Protein.	Fat.	Carbo- hydrates.	Fuel value.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
March 24.....	118.3	16.2	888.0	4,170
25.....	117.3	9.9	983.1	4,490
26.....	74.6	37.2	553.7	2,845
Average for March 24 and 25.....	117.8	13.0	935.5	4,330

Urine was collected during the three days of the study, the total amount being 2,800 cubic centimeters, with a specific gravity of 1.028, and containing 45.47 grams nitrogen. This gives an average daily elimination of 933 cubic centimeters of urine, containing 15.15 grams of nitrogen, corresponding to 95 grams of protein.

This study is the only one of this class found, although K. Kajita determined the amount of nitrogen in the urine eliminated by a rice cleaner in connection with studies of urine previously mentioned (p. 15). The results obtained are interesting for comparison here. The subject was 28 years old, and weighed 56.6 kilograms. Urine was collected in 24-hour periods during seven consecutive days in August, 1889 (?), and the nitrogen in it was determined daily by the Kjeldahl method. The amount of nitrogen in the urine eliminated varied from 14.96 to 24.92 grams per day, and averaged 15.6 grams, corresponding to 97.5 grams protein per day. Assuming the subject to have been in nitrogen equilibrium, and the digestibility of the protein in the diet to be 87 per cent (see p. 206), the total protein in the food consumed by this subject would be 112 grams per day.

DIETARY STUDY WITH A JINRIKISHA MAN (No. 26).

This study was made by J. Tsuboi.^a It covered four days, from breakfast on December 14 to supper on December 17, 1888 (?), inclusive. The subject, F. S., was a very strong jinrikisha man in Tokyo, who had been engaged in the business for six years. He was 33 years old and weighed 62.4 kilograms. He was engaged each day of the

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 3 (1889), p. 1353.

study, drawing the carriage with one man in it, and on the several days covered the following distances: December 14, 30 miles; December 15, 10 miles; December 16, 5 miles, and December 17, 15 miles.

As the occupation of the subject did not allow him to take his meals always at the same place he was provided with a Japanese balance, which is very compact and convenient to carry, and weighed the cooked food which he ate, at the same time making a careful note regarding the kind and quality of the food eaten. He was very intelligent and accurate in his habits, and the data he gave were believed to be perfectly reliable.

The diet contained both animal and vegetable foods, meat or fish being used regularly. The heaviest meal of the day was always supper, or when the subject had finished his day's work. Sake was usually taken with this meal.

Analyses were made of samples of the miscellaneous fish food, monaka cake, ginger, and radish pickled in miso.

TABLE 22.—Results of dietary study No. 26.

Kinds and amounts of food per person 4 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
Meats: Beef, 600 grams.....	31.4	7.8	0.7	.....
Fish: Porgy, 300 grams; tunny, 86 grams; shellfish, with con- diments, 143 grams; miscellaneous fish dish (35), 251 grams.	25.2	3.2	4.2	.....
Eggs, 263 grams.....	8.2	7.9	.3	.....
Total animal food.....	64.8	18.9	5.2	.....
<i>Vegetable food.</i>				
Cereal: Rice, cooked, 11,681 grams.....	81.1	4.7	936.9	.....
Sugar and starches: Cake (73), 142.5 grams.....	1.6	1.1	19.7	.....
Vegetables: Burdock, 169 grams; carrots, cooked, 244 grams; eggplants, pickled, 180 grams; ginger, pickled (140), 19 grams; lotus rhizome and carrots, cooked, 83 grams; radish, pickled (124), 574 grams; orange, 38 grams.....	10.1	.9	38.2	.....
Total vegetable food.....	92.8	6.7	994.8	.....
Beverage: Sake (126), 551 grams.....			30.7	.....
Total food { Total nutrients	157.6	25.6	1,030.7	
Digestible nutrients	137.1	21.8	1,010.1	5,050

This study is especially interesting, since the subject belonged to a class concerning whom very much has been said and written. In the first place, the amount of work done by these runners is on the whole very large, although that done by the subject of this study was not especially so, the most noticeable instance being on December 14, when he drew the jinrikisha containing one man 30 miles. It is to be remembered that in drawing the carriages the men run practically all the time. The distance between Tokyo and Nikko, a popular resort, is nearly 68 miles. Some of the jinrikisha runners draw the carriage that distance in about fourteen hours and thirty minutes in one day. One record shows that a jinrikisha man drew

a carriage containing a heavy passenger nearly 45 miles in eight hours and forty-five minutes on a hot day in August.

Moreover, it has been generally believed that these men live entirely on a very simple rice diet. The diet of the subject of this study, supplying 158 grams of protein, and having a total fuel value of 5,050 calories per day, was both abundant and rather varied. The protein was obtained from different sources, in the following proportions: From total animal food, 41.1 per cent; from fish, 16 per cent; from meat and eggs, 25.1 per cent; from rice, 51.5 per cent, and other vegetable foods, 7.4 per cent. Nearly 94 per cent of the total carbohydrates was obtained from rice. That rice formed the principal food is indisputable, though the fact that more than 40 per cent of the total protein in the diet was derived from animal food is especially worthy of notice.

Contrary to popular belief, it is the general impression of close observers that these jinrikisha men commonly spend a comparatively large part of their income on animal food. According to the observations of Tiegel,^a the jinrikisha men eat a large amount of rice during their working periods, taking meals every two or three hours, but, during the period of rest they eat considerable quantities of fish, eggs, beef, and pork. With regard to the opinions concerning the small amount of protein ("Eiweissarmuth") in the diet of these people, he believes that the condition has been considerably misrepresented. Gardiner,^b probably basing his discussion on Tiegel's report, writes as follows in discussing the dietetic value of sugars: "During their period of rest they (jinrikisha runners) consume large quantities of meat in order to build up strong muscles, but while actually working they subsist mainly on rice—a food consisting chiefly of an easily digestible form of polysaccharid, starch." On the other hand, in the opinion of Baelz,^c jinrikisha men prefer vegetable to animal food. The diets of two runners on whom he made observations consisted almost entirely of rice, potatoes, barley, chestnuts, and lily bulbs, and furnished less protein than the commonly accepted dietary standard suggests. However, in his paper these dietaries were not reported in full.

Although no other complete study similar to No. 26 was found, K. Kajita, in the investigations of urine previously mentioned (p.15), determined the quantities of nitrogen in the urine eliminated by two jinrikisha men, and the results are interesting for comparison with this study. One subject was 39 years old and weighed 69.5 kilograms. He was occupied in drawing the carriage with one or two persons for distances varying from 7.5 to 15 miles daily during the experimental

^a Arch. Physiol. [Pflüger], 31 (1883), p. 607.

^b Brit. Med. Jour., 1901, p. 1010.

^c Berlin. Klin. Wehnschr., 38-(1901), p. 689.

period. Urine was collected each day, under the careful supervision of the investigator, for seven consecutive days in the middle of March, 1889, and nitrogen was determined daily. The amount of nitrogen in the urine varied from 17.95 to 22.43 grams, and averaged 20.62 grams per day, corresponding to 128.9 grams of protein. If the subject was in nitrogen equilibrium, and the digestibility of the protein was 87 per cent, the total amount of protein in the food consumed by the subject would be about 148 grams, which agrees well with the result of observation in dietary study No. 26.

The other subject was 40 years old and weighed 54.4 kilograms. During the first five days of the study he drew the carriage containing one person an average distance of 10 miles per day. During the last two days he did practically no work. Urine was collected each day during the seven consecutive days in August, 1889 (?), and nitrogen was determined daily by the Kjeldahl method. The amount of nitrogen in the urine varied from 8.93 to 13.84 grams per day, and averaged 11.17 grams, corresponding to 69.8 grams of protein. According to the assumptions suggested above regarding nitrogen balance and digestibility, the total amount of protein in the food consumed by the subject would be 80 grams. This is very small in comparison with the results of the two preceding observations.

DIETARY STUDIES WITH STUDENTS (Nos. 31-33).

These studies were made by J. Tsuboi and H. Murata^a, for the purpose of determining the amounts and digestibility of the nutrients in the diet of students in a dormitory of the University at Tokyo. The results of the dietary studies are here given. The digestion experiments (Nos. 25-27) will be found on pages 156 to 158.

Three studies, each with a single subject, were conducted simultaneously, beginning July 30, 1887, and continuing three days. The subject of study No. 31, J. T., was a physician in good health, 26 years old, and weighing 40.2 kilograms, engaged eight hours each day in the laboratory of the Hygienic Institute. The subject of No. 32, M. J., was an assistant in the Hygienic Institute, 23 years old, and averaging 40.5 kilograms in weight during the period. The subject of No. 33 was H. M., a medical student, 26 years old, weighing 51 kilograms.

The food consisted of the regular diet of the dormitory, which was of a mixed character. Tea and water were the only drinks used during the study. Though the diet was the same in kind for each subject, the amounts eaten were different. At each meal, four portions of the cooked foods used were taken from the kitchen, and each was weighed separately. One portion was reserved for analysis, and the

^a Mitt. Med. Fakultät, Univ. Tokyo, 1 (1890), p. 359.

others were eaten by the subjects. It may be mentioned that it is customary in Japan to serve all cooked foods for each person in individual dishes, the only exception to this being cooked rice, the total amount of which is usually placed in one dish and served ad libitum. The amount of rice actually eaten by each subject was weighed separately.

The percentage of water was determined in each sample of food obtained at each meal, in order that the amount of water-free material actually eaten might be ascertained. For this determination the weighed cooked food was partially dried in a water bath, then cooled and weighed. It was then pulverized, and further dried at 110° C. until the weight was constant.

In the case of beef, fish, vermicelli, miso, and pickled radish, it was believed that the ingredients other than water could be assumed with sufficient accuracy for the purpose of these studies from the results of previous analyses of such materials, but complete analyses of all the other samples of food were made. Nitrogen was determined by the Will-Varrentrapp method, and fat by the usual Soxhlet method; carbohydrates were estimated by difference. Chlorin was determined by titrating an aqueous solution against a standard solution of silver nitrate, and from the amount of chlorin determined the amount of sodium chlorid was calculated. The values for neither the assumed nor the determined percentage composition, however, were reported.

The data of the studies are given in the following table:

TABLE 23.—Results of dietary studies Nos. 31–33.

Kind and amounts of food per person 3 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 31.</i>				
ANIMAL FOOD.				
Meats: Beef, 87 grams; beef, broiled with oil, 105 grams.....	<i>Grams.</i> 12.0	<i>Grams.</i> 7.5	<i>Grams.</i> 8.0	<i>Calories.</i>
Fish and eggs: Fish, 33 grams; shellfish ^a , 8 grams; loach and eggs cooked together, 84 grams; omelet, 113 grams.....	7.1	6.8	7.8	.....
Total animal food.....	19.1	14.3	15.8	.....
VEGETABLE FOOD.				
Cereals: Rice, cooked, 3,818 grams; vermicelli, 44 grams.....	30.9	3.9	400.5	.....
Vegetables: String beans, burdock, carrots, and onion, cooked together, 193 grams; cucumber, 21 grams; cucum- ber, pickled, 17 grams; eggplant, pickled, 33 grams; ginger, 17 grams; gourd, 71 grams; vegetable soup, 984 grams; scallion, 11 grams; salad, 21 grams; radish, pickled, 108 grams.....	3.5	.8	24.1	.....
Total vegetable food.....	34.4	4.7	424.6	.....
Total food	53.5	19.0	440.4	.....
Total nutrients.....	<i>b</i> 48.3	<i>b</i> 15.5	<i>b</i> 438.2	2,201
Digestible nutrients.....				

^a *Corbicula atrata*.

^b See page 157.

TABLE 23.—Results of dietary studies Nos. 31-33—Continued.

Kind and amounts of food per person 3 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
Study No. 32.				
ANIMAL FOOD.				
Meat: Beef, 82 grams; beef, broiled with oil, 113 grams.....	Grams. 11.9	Grams. 7.8	Grams. 8.5	Calories.
Fish and eggs: Fish, 30 grams; shellfish, ^a 7 grams; loach and eggs cooked together, 84 grams; omelet, 133 grams.....	7.4	7.7	8.3	.....
Total animal food.....	19.3	15.5	16.8	.....
VEGETABLE FOOD.				
Cereals: Rice, cooked, 4,372 grams; vermicelli, 41 grams.....	35.2	5.7	456.2	.....
Vegetables: String beans, burdock, carrots, and onion cooked together, 213 grams; cucumber, 20 grams; cucum- ber pickles, 18 grams; eggplant, pickled, 29 grams; ginger, 11 grams; gourd, 81 grams; salad, 25 grams; scallion 10 grams; vegetable soup, 911 grams; radish, pickled, 71 grams.....	3.3	.8	22.2	.....
Total vegetable food.....	38.5	6.5	478.4	.....
Total food {Total nutrients.....	57.8	22.0	495.2	.....
{Digestible nutrients.....	b 46.5	b 19.7	485.3	2,430
Study No. 33.				
ANIMAL FOOD.				
Meat: Beef, 76 grams; beef, broiled with oil, 52 grams.....	8.8	4.4	3.8	.....
Fish and eggs: Fish, 36 grams; shellfish, ^a 5 grams; loach and eggs cooked together, ^c 77 grams; omelet, 93 grams.....	6.5	5.8	6.9	.....
Total animal food.....	15.3	10.2	10.7	.....
VEGETABLE FOOD.				
Cereals: Rice, cooked, 3,997 grams; vermicelli, 33 grams.....	32.2	4.1	418.3	.....
Vegetables: String beans, burdock, carrots, onion, etc., cooked together, ^c 204 grams; cucumber, 21 grams; cucum- ber pickles, 17 grams; eggplant, pickled, 29 grams; ginger, 20 grams; gourd, 53 grams; salad, 15 grams; scallion 11 grams; vegetable soup, 840 grams; radish, pickled, 94 grams	3.3	.9	23.7	.....
Total vegetable food.....	35.5	5.0	442.0	.....
Total food {Total nutrients.....	50.8	15.2	452.7	.....
{Digestible nutrients.....	b 42.8	b 14.0	b 438.2	2,163

^a *Corbicula atrata*.^b See pages 157, 158.

^c The amount of loach and eggs cooked, and that of cooked vegetables were given together in the original. Taking the average of the relative proportions of these items in diets Nos. 31 and 32, the amount of loach and eggs was assumed to be 77 grams. Its percentage composition was calculated from the amount and nutrients given in diets Nos. 31 and 32. The percentage composition estimated is as follows: Protein, 5.14 per cent; fat, 6.77 per cent; carbohydrates, 17.58 per cent.

In the average of the three individual tests the diet supplied 54 grams of protein, 19 grams of fat, and 463 grams of carbohydrates per man per day, with a fuel value of 2,265 calories. Although a variety of animal foods, including fish, and eggs, were used, the total amount of protein supplied from animal food was small in comparison with that from vegetable foods. Animal food supplied on the average 33 per cent of the total protein of the diet, whereas rice alone supplied on the average nearly 61 per cent. Nearly 92 per cent of the total carbohydrates of the diet was obtained from rice.

Two facts are to be especially noted in connection with this study. In the first place the subjects, though fully grown, were light in weight; in the second place the study was made during the hot summer period.

DIETARY STUDY WITH MARINES (No. 34.)

This study was made with marines on board the battle ship *Yeyeyama*, during the two months of July and September, 1891. The results were reported by S. Yamashita,^a a navy surgeon. During the month of July the ship was cruising near the coast of Japan, during September it was lying in harbors of Yokosuka and Mikako. Neither the number nor weight of the subjects was given in the report. The food statistics were not given in detail for the two months of the study, but simply the amount of each kind of food and the nutrients supplied were reported on the basis of the average per man per day for the whole period. The weights of meats and fish were those of the edible portion. Preserved meats and fish were used, but their weights were recalculated and reported in equivalent values for fresh meats or fish. The same is true of vegetables. In converting the data from Japanese weights to grams, the investigator assumed that 1 momme, the unit of Japanese weight, is equivalent to 4 grams. The original figures have been retained here for the most part, but wherever recalculation was necessary this assumption has been followed.

TABLE 24.—Results of dietary study No. 34.

Kinds and amounts of food per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats, 250 grams.....	51.3	21.0	.....	.....
Poultry, 32 grams.....	6.8	1.3	.....	.....
Fish, 108 grams.....	19.6	3.1	.....	.....
Eggs, 1 gram.....	.2	.2	.....	.....
Milk (condensed milk), 0.6 gram.....	.....	.1	0.3	.....
Fats, 15 grams.....	.....	14.5	.....	.....
Total animal food.....	77.9	40.2	.3	.....
<i>Vegetable food.</i>				
Cereals: Bread, 414 grams; dry bread, 7 grams; rice, 276 grams; wheat flour, 13 grams.....	44.2	8.7	458.9	.....
Sugar, 27 grams.....	.....	.....	26.3	.....
Legumes and their preparations: Legumes, 8 grams; miso, 72 grams; shoyu, 21 grams.....	9.9	.1	5.9	.....
Vegetables, 692 grams.....	12.4	2.1	81.7	.....
Total vegetable food.....	66.5	10.9	572.8	.....
Total food { Total nutrients.....	144.4	51.1	^a 573.1	.....
{ Digestible nutrients.....	125.6	43.4	561.6	3,320
Condiments: Barley, roasted, 6 grams; tea, 3 grams; table salt, 9 grams; vinegar, 4 grams; some mustard and pepper.				

^a In the original the total amount of carbohydrates was given as 378.4 grams, and attention was called to the smallness of this value. It is to be remarked, however, that the 414 grams of bread was calculated to contain only 21.64 grams of carbohydrates, which is obviously too small an amount—about one-tenth what it should be. Apparently there was an error in the decimal, and the amount should probably be 216.4 grams. In this table it has been assumed that such was the case.

DIETARY STUDIES WITH GROUPS OF SOLDIERS (Nos. 43–52).

An extensive investigation^b of the food consumption in the army in different parts of the country and in different seasons of the year

^a Kaigun Iji Hokoku Saiyo (Med. Rpt. Imp. Navy), 1891, No. 19, p. 79.

^b Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1892, No. 52, Sup. No. 14, p. 529.

was conducted in 1888 and 1889 by army surgeons with groups of soldiers located in different districts. Altogether 24 districts were represented, from Hakodate on the north to Okinawa in the south, and four studies, one each season of the year, were made with the group of soldiers in each district. The studies were extended to the Imperial Guard, and to six divisions, each representing five different classes of soldiers, namely, infantry, cavalry, field artillery, engineers, and provision corps.

The following statistics regarding the average ages and weights of the soldiers are interesting. Period 1 refers to the time of enrollment, and period 2 is one year later.

TABLE 25.—*Age and weight of subjects of dietary studies Nos. 43-52.*

Class	Period.	Number of soldiers.	Age.		Weight.		Increase in weight.
			<i>Yrs.</i>	<i>mos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	
Infantry.....	1	34,864	20	10	58.23	3.17	
	2	33,097	21	10	61.40		
Cavalry.....	1	590	20	5	57.54	3.68	
	2	566	21	5	61.22		
Artillery.....	1	2,724	20	11	62.86	2.75	
	2	2,586	21	11	65.51		
Engineers.....	1	1,384	20	11	58.24	2.63	
	2	1,361	21	11	60.87		
Provision corps.....	1	844	20	8	56.49	2.55	
	2	777	21	8	59.04		

In the majority of cases each study continued 7 days, though some were 10, 30, and even 366 days in length. The number of persons included in each study was not reported and very few details regarding the methods of study were given in the original report. It was stated that in some cases the cooked foods used were weighed and the amounts of waste were subtracted, and in other cases the food materials were weighed before cooking. Nothing was said about the waste in the latter. No analyses were made in connection with these studies. The amounts of nutrients in the foods used were calculated by means of available data regarding percentage composition of similar materials.

The rations varied somewhat in the different divisions, and again in different battalions and regiments of the same division. For example in some cases a rice-barley diet was preferred to a rice diet, and in other cases more or less bread was used. The proportions of rice and barley used were not uniform in different districts, but 3 or 4 parts of barley to 6 or 7 parts of rice were the most common proportions. Beef, pork, chicken, eggs, fish, and various kinds of vegetables formed the other regular constituents of the ration.

The results as given in the original report do not include the usual statistics regarding the kinds and amounts of different foods actually used in the different studies. They show simply the amounts of nutrients in the food consumed per man per day, in the averages of

considerable numbers of similar studies. These data are summarized for the different classes of soldiers in the following table. From what has been stated above it seems possible that the figures here given may include those for waste in some of the studies, but it is doubtful whether the waste in those studies in which it was not recorded would be large enough to have much effect upon the average results per man per day.

TABLE 26.—Results of dietary studies Nos. 43-52.

Class of soldiers.	Study No.	Date.	Number of studies in average.		Nutrients and energy per man per day.			
					Protein.	Fat.	Carbohydrates.	Fuel value.
					<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Infantry...	{ 43	1888	66	Total nutrients.....	117.7	21.8	651.2	
		1889	98	Total nutrients.....	127.3	22.0	674.9	
				Average {	123.4	21.9	665.4	
				Digestible nutrients ^a ..	107.4	18.6	652.1	3,385
Cavalry....	{ 45	1888	6	Total nutrients.....	119.1	18.8	783.5	
		1889	13	Total nutrients.....	126.3	19.6	679.6	
				Average {	124.0	19.3	712.4	
				Digestible nutrients ^a ..	107.0	16.4	698.2	3,561
Artillery...	{ 47	1888	12	Total nutrients.....	121.6	24.8	641.0	
		1889	14	Total nutrients.....	120.2	20.7	631.8	
				Average {	120.9	21.1	636.1	
				Digestible nutrients ^a ..	105.2	17.9	623.4	3,248
Engineer corps.	{ 49	1888	13	Total nutrients.....	134.9	23.8	657.7	
		1889	19	Total nutrients.....	134.9	22.6	620.5	
				Average {	134.9	23.1	635.6	
				Digestible nutrients ^a ..	117.4	19.6	622.9	3,317
Provision corps.	{ 51	1888	8	Total nutrients.....	118.5	24.6	632.0	
		1889	12	Total nutrients.....	107.3	21.8	628.0	
				Average {	111.8	23.0	629.6	
				Digestible nutrients ^a ..	97.3	19.6	617.0	3,203

^a Calculated by factors for digestibility of nutrients in ordinary mixed diet. (See p. 206.)

DIETARY STUDIES WITH MILITARY CADETS (Nos. 53-58).

Ten studies^a were made with cadets in four military schools during the same years and according to the same plan as explained in connection with studies Nos. 43-52. The ages and weights of the individuals were not given in the original report. In the cases in which the duration was recorded each study continued seven to twelve days.

The kinds of food used were essentially the same as in the regular army ration, and consisted of rice, rice-barley, bread, meat, fish, eggs, and vegetables. The foods were weighed usually before cooking, but in some cases the cooked foods were weighed. The results as given in the original reports show the amounts of nutrients in the food consumed per man per day. They may possibly include the nutrients of the waste.

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1892, No. 52, Sup. No. 14, p. 529.

TABLE 27.—Results of dietary studies Nos. 53-58.

Study No.	Date.	Subjects.	Duration.	Number of studies included.	Food.	Nutrients and energy per man per day.			
						Protein.	Fat.	Carbo-hydrates.	Fuel value.
53	1889	Cadets of Shikwan-Gakko...	Days. 19	2	Mixed diet, vegetable and animal.	Grams. 125	Grams. 24	Grams. 591	Calories. 3,103
54	1888	Cadets of Yonen-Gakko...	(?)	1	do.	108.8	20.4	579.2	2,859
55	1889	Cadets of Yonen-Gakko...	21	2	do.	113	26	539	2,883
56	1888	Cadets of Hoheishateki-Gakko.	7	1	do.	98.3	22.1	528.2	2,859
57	1889	Cadets of Hoheishateki-Gakko.	7	1	do.	116	22	550	2,883
58	1888	Cadets of Toyama-Gakko...	(?)	3	do.	100.9	18.7	539	2,883
						108	25	630	3,204
						94	21.3	617.4	3,439
						112	15	704	3,439
						97.4	12.8	689.9	3,439
						114	27	695	3,510
						99.2	23.0	681.1	3,510

DIETARY STUDY WITH MILITARY NURSES (No. 66).

This study was made by G. Oi^a with 40 military nurses (males). It began December 13, 1885, and continued seven days. The principal food was rice but the diet contained also fish and vegetables. The amounts of cooked food eaten were weighed. The cooked rice was sampled and a composite sample of the supplemental food was also obtained, and both were analyzed, the results of the analyses being given in Table 6. The average amount of cooked rice per man per meal was 604 grams, having a water content of 65.32 per cent. The average amount of accessory food was 229.6 grams, having a water content of 83.62 per cent. The average results per man per day were given in the original report. The amounts of food and nutrients in Table 28 are those actually eaten.

TABLE 28.—Results of dietary study No. 66.

Kinds and amounts of food per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
	Grams.	Grams.	Grams.	Calories.
Rice, cooked, 1,811 grams.....	49.6	5.6	567.9	
Supplemental food, 689 grams	34.1	14.3	43.1	
Total food.....	83.7	19.9	611.0	
Total nutrients.....	72.8	16.9	598.8	
Digestible nutrients.....				2,991

Feces and urine were collected during the experiment, and the percentage of nitrogen in them was determined. The average amounts per man per day were as follows: Feces, 150 grams, containing 0.02 gram nitrogen; urine, 1,200 grams, containing 11.92 grams nitrogen. This study has not been included in either the digestion or nitrogen metabolism experiments, however, as the amount of nitrogen in the feces seems so small as to suggest either an error or an abnormal result.

DIETARY STUDIES WITH INDIVIDUAL SOLDIERS (Nos. 74-92).

An investigation was conducted by Mori, Oi, and Iishima, at the Army Medical College, Tokyo, in 1889, for the purpose of determining the relative merits of the three following rations in use in the army:

(1) Rice ration, consisting chiefly of rice, fish, and vegetables, with a moderate quantity of beef. (2) Rice-barley ration, same as the rice ration except that barley was substituted for part of the rice, in the proportion of about 3 parts of the former to 7 of the latter. (3) European or bread ration, consisting chiefly of bread, meat, and vegetables, but with rice in place of bread at one meal every three days. The investigation comprised not only a study of the amounts of food eaten with each ration, and of nutrients and energy supplied,

^a Gun-i Gakko Gyofu (Arb. K. Japan. Militär-Ärztl. Lehranst.), [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 108.

but also determinations of the digestibility of the nutrients in each ration. The statistics of food consumed and nutrients supplied are here summarized; the digestion experiments (Nos. 51-69) are given on pages 158 to 163.

For the study of each ration 6 infantry soldiers were obtained from a battalion in which the particular ration was used, so that there should be no change of diet due to the study. The physical exercises of the subjects were continued as usual during the period of the studies. The men were not limited as to the amount of food eaten, but each ate as much as he desired of the different kinds of food in the ration. The quantity of food served to each one and that remaining uneaten was weighed at each meal for eight days, and from these data the quantities actually eaten were learned. The cooked foods and the waste were analyzed. In the case of cooked rice, rice-barley, and bread, the samples for analysis were composites; but soup was analyzed every time it was used.

In the original report the amounts of food eaten and of nutrients supplied were given by separate days for each subject; but these data have been summarized in the table below to show the total quantities of food and of nutrients and energy for the whole period for each subject, and the average amounts of nutrients and energy per day.

Studies Nos. 74-79 (rice ration).^a—These studies were made August 12 to 19, 1889. The diet consisted of rice and soup, and supplemental food, comprising beef, pork, fish, and vegetables. The ages and weights of the 6 subjects were as follows:

TABLE 29.—Age and weight of subjects in dietary studies Nos. 74-79.

Subject in—	Age.	Weight.	Subject in—	Age.	Weight.
	<i>Years.</i>	<i>Kilos.</i>		<i>Years.</i>	<i>Kilos.</i>
Study No. 74.....	24	54.65	Study No. 77.....	23	59.65
Study No. 75.....	24	55.22	Study No. 78.....	23	56.81
Study No. 76.....	23	66.71	Study No. 79.....	24	56.30

Studies Nos. 80-85 (rice-barley ration).^b—These studies were made October 15 to 22, 1889. The diet consisted of rice-barley mixture and soup, supplemented by beef, pork, chicken, fish, and vegetables. The ages and weights of the 6 subjects were as follows:

TABLE 30.—Age and weight of subjects in dietary studies Nos. 80-85.

Subject in—	Age.	Weight.	Subject in—	Age.	Weight.
	<i>Years.</i>	<i>Kilos.</i>		<i>Years.</i>	<i>Kilos.</i>
Study No. 80.....	23	56.50	Study No. 83.....	22	57.45
Study No. 81.....	24	61.00	Study No. 84.....	22	59.50
Study No. 82.....	22	61.70	Study No. 85.....	22	56.70

^a Gun-i Gakko Gyofu; (Arb. K. Japan. Militär-Arztl. Lehranst.), [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 1.

^b Ibid., p. 35.

Study No. 86 (barley ration).^a—Simultaneous with studies Nos. 80–85, a single study was made with one subject, an army nurse, 46 years old and weighing 52.2 kilograms, in which the diet was exactly the same as the rice-barley ration, except that barley alone was used in place of the rice-barley mixture, the supplemental foods remaining the same. The digestibility of the ration was determined, as in the case of the other rations. The purpose was to compare these two rations, though a ration in which barley is the only cereal has never been adopted in the army. The subject was able to continue in this ration for eight days only with difficulty.

Studies Nos. 87–92 (European or bread ration).^b—These studies were made December 13 to 20, 1889. The diet consisted principally of bread and soup, supplemented by beef, pork, eggs, fish, and vegetables; but with the evening meal every third day, rice was served instead of bread, and during the period of these studies rice was thus served three times. The ages and weights of the subjects were as follows:

TABLE 31.—*Age and weight of subjects in dietary studies Nos. 87–92.*

Subject in—	Age.	Weight.	Subject in—	Age.	Weight.
	<i>Years.</i>	<i>Kilos.</i>		<i>Years.</i>	<i>Kilos.</i>
Study No. 87.....	24	57.75	Study No. 90.....	23	58.00
Study No. 88.....	24	61.65	Study No. 91.....	24	60.15
Study No. 89.....	24	60.85	Study No. 92.....	24	54.60

The results of the dietary studies follow:

TABLE 32.—*Results of dietary studies with rice ration, Nos. 74–79.*

Study No.	Kinds and amounts of food actually eaten.	Nutrients and energy.			
		Protein.	Fat.	Carbo-hydrates.	Fuel value.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
74	Rice, cooked, 11,823 grams.....	401.1	24.9	3,398.0	
	Soup, 2,020 grams.....	35.7	6.5	43.3	
	Supplemental food, 4,285 grams.....	267.4	86.5	567.1	
	Total for 8 days.....	704.2	117.9	4,008.4	
	Average per day {	88.0	14.7	501.1	
		c 75.1	c 12.5	c 491.6	2,513
	Digestible nutrients.....				
75	Rice, cooked, 11,397 grams.....	387.4	24.0	3,812.9	
	Soup, 2,055 grams.....	41.7	7.6	47.6	
	Supplemental food, 4,332 grams.....	270.0	89.2	533.3	
	Total for 8 days.....	699.1	120.8	4,393.8	
	Average per day {	87.4	15.1	549.2	
		c 74.7	c 12.8	c 539.9	2,716
	Digestible nutrients.....				

^a Gun-i Gakko Gyofu; (Arb. K. Japan. Militär-Ärztl. Lehranst.), [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 35.

^b *Ibid.*, p. 60.

^c See page 160.

TABLE 32.—Results of dietary studies with rice ration, Nos. 74-79—Continued.

Study No.	Kinds and amounts of food actually eaten.	Nutrients and energy.			
		Protein.	Fat.	Carbo- hydrates.	Fuel value.
		Grams.	Grams.	Grams.	Calories.
76	Rice, cooked, 11,706 grams.....	397.3	24.6	3,916.7	.....
	Soup, 2,185 grams.....	45.5	7.4	53.5	.....
	Supplemental food, 4,542 grams.....	275.4	94.9	594.4	.....
	Total for 8 days.....	718.2	126.9	4,594.6	.....
	Average per day { Total nutrients.....	89.8	15.9	570.6	.....
	Digestible nutrients.....	α 75.8	13.5	α 563.8	2,828
77	Rice, cooked, 11,426 grams.....	387.6	24.0	3,823.5	.....
	Soup, 2,055 grams.....	41.7	7.7	47.6	.....
	Supplemental food, 4,435 grams.....	264.5	89.3	550.6	.....
	Total for 8 days.....	693.8	121.0	4,421.7	.....
	Average per day { Total nutrients.....	86.7	15.1	552.7	.....
	Digestible nutrients.....	α 70.6	12.8	α 542.7	2,710
78	Rice, cooked, 11,594 grams.....	393.4	24.4	3,878.5	.....
	Soup, 2,235 grams.....	41.7	7.7	59.0	.....
	Supplemental food, 3,789 grams.....	238.7	81.8	506.1	.....
	Total for 8 days.....	673.8	113.9	4,443.6	.....
	Average per day { Total nutrients.....	84.2	14.2	555.5	.....
	Digestible nutrients.....	α 69.8	12.1	α 549.9	2,730
79	Rice, cooked, 9,826 grams.....	333.4	20.7	3,287.9	.....
	Soup, 1,695 grams.....	33.6	7.1	35.5	.....
	Supplemental food, 3,417 grams.....	223.7	81.2	468.4	.....
	Total for 8 days.....	590.7	109.0	3,791.8	.....
	Average per day { Total nutrients.....	73.8	13.6	474.0	.....
	Digestible nutrients.....	α 61.6	11.6	α 467.4	2,343
	Average of 6 studies { Total nutrients.....	85.0	14.8	533.8	.....
	Digestible nutrients.....	α 71.2	12.3	α 525.8	2,637

TABLE 33.—Results of dietary studies with rice-barley ration, Nos. 80-85.

Study No.	Kinds and amounts of food actually eaten.	Nutrients and energy.			
		Protein.	Fat.	Carbo- hydrates.	Fuel value.
		Grams.	Grams.	Grams.	Calories.
80	Rice-barley, cooked, 11,719 grams.....	284.7	8.8	3,120.4	.....
	Rice dumpling, 995 grams.....	24.4	.7	262.2	.....
	Soup, 3,520 grams.....	106.9	35.0	108.3	.....
	Supplemental food, 3,371 grams.....	175.6	47.0	247.3	.....
	Total for 8 days.....	591.6	91.5	3,738.2	.....
	Average per day { Total nutrients.....	74.0	11.4	467.3	.....
	Digestible nutrients.....	α 53.8	9.7	α 452.3	2,227
81	Rice-barley, cooked, 12,359 grams.....	302.6	8.5	3,255.8	.....
	Rice dumpling, 630 grams.....	20.0	1.4	201.6	.....
	Soup, 3,685 grams.....	107.2	35.1	114.4	.....
	Supplemental food, 4,137 grams.....	208.6	61.1	306.3	.....
	Total for 8 days.....	638.4	106.1	3,878.1	.....
	Average per day { Total nutrients.....	79.8	13.3	484.8	.....
	Digestible nutrients.....	α 58.8	11.3	467.8	2,330
82	Rice-barley cooked, 12,153 grams.....	297.6	8.3	3,205.1	.....
	Rice dumpling, 570 grams.....	18.0	1.3	181.4	.....
	Soup, 3,885 grams.....	112.4	37.1	118.6	.....
	Supplemental food, 4,014 grams.....	203.4	59.1	287.3	.....
	Total for 8 days.....	631.4	105.8	3,792.4	.....
	Average per day { Total nutrients.....	78.9	13.2	474.1	.....
	Digestible nutrients.....	α 58.7	11.2	α 457.5	2,285

α See pages 160-163.

TABLE 33.—*Results of dietary studies with rice-barley ration, Nos. 80–85—Continued.*

Study No.	Kinds and amounts of food actually eaten.	Nutrients and energy.			
		Protein.	Fat.	Carbohy- drates.	Fuel value.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
83	Rice-barley, cooked, 12,158 grams.....	297.7	8.3	3,222.9	
	Rice dumpling, 595 grams.....	18.9	1.3	190.4	
	Soup, 3,695 grams.....	107.2	35.1	120.3	
	Supplemental food, 3,924 grams.....	200.3	58.0	290.8	
	Total for 8 days.....	624.1	102.7	3,824.4	
	Average per day { Total nutrients.....	78.0	12.8	478.1	
84	Rice-barley, cooked, 12,005 grams.....	293.9	8.2	3,174.5	
	Rice dumpling, 560 grams.....	17.8	1.2	179.2	
	Soup, 4,070 grams.....	117.1	39.0	115.4	
	Supplemental food, 3,931 grams.....	197.3	55.7	291.1	
	Total for 8 days.....	626.1	104.1	3,761.2	
	Average per day { Total nutrients.....	78.3	13.0	470.1	
85	Rice-barley, cooked, 12,337 grams.....	301.9	8.4	3,241.3	
	Rice dumpling, 555 grams.....	17.6	1.2	177.6	
	Soup, 4,105 grams.....	123.1	39.8	131.8	
	Supplemental food, 3,940 grams.....	169.6	57.9	291.5	
	Total for 8 days.....	639.2	107.3	3,842.2	
	Average per day { Total nutrients.....	79.9	13.4	480.3	
	Average of 6 studies { Total nutrients.....	78.1	12.8	475.8	
		55.2	10.9	459.6	2,276

TABLE 34.—*Results of dietary study with barley ration, No. 86.*

Kinds and amounts of food actually eaten.	Nutrients and energy.			
	Protein.	Fat.	Carbohy- drates.	Fuel value.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Barley, cooked, 12,654 grams.....	240.6	8.9	1,955.4	
Soup, 3,315 grams.....	101.6	32.7	99.5	
Supplemental food, 4,097 grams.....	204.4	59.1	292.6	
Total for 8 days.....	546.6	100.7	2,347.5	
Average per day { Total nutrients.....	68.3	12.6	293.4	
	41.8	10.7	257.9	1,368

TABLE 35.—*Results of dietary studies with European or bread ration, Nos. 87–92.*

Study No.	Kinds and amounts of food actually eaten.	Nutrients and energy.			
		Protein.	Fat.	Carbohy- drates.	Fuel value.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
87	Bread, 4,368 grams.....	202.0	2.4	2,464.1	
	Rice, cooked, 1,572 grams.....	52.2	.7	507.3	
	Soup, 4,717 grams.....	91.5	26.3	152.6	
	Supplemental food, 4,121 grams.....	293.9	151.7	422.4	
	Total for 8 days.....	639.6	181.1	3,546.4	
	Average per day { Total nutrients.....	80.0	22.6	443.3	
		63.0	19.2	426.9	2,251

a See pages 160-163.

TABLE 35.—*Results of dietary studies with European or bread ration, Nos. 87-92—Continued.*

Study No.	Kinds and amounts of food actually taken.	Nutrients and energy.			
		Protein.	Fat.	Carbo- hydrates.	Fuel value.
		Grams.	Grams.	Grams.	Calories.
88	Bread, 4,345 grams.....	200.9	2.4	2,456.3	.....
	Rice, cooked, 1,410 grams.....	46.7	.6	455.2	.....
	Soup, 4,992 grams.....	96.7	27.8	165.2	.....
	Supplemental food, 4,055 grams.....	290.5	132.3	471.2	.....
	Total for 8 days.....	634.8	163.1	3,547.9	.....
	Average per day { Total nutrients.....	79.4	20.4	443.5	.....
89	Bread, 4,417 grams.....	204.4	2.4	2,484.4	.....
	Rice, cooked, 1,456 grams.....	48.2	.7	471.1	.....
	Soup, 4,717 grams.....	91.4	26.2	152.6	.....
	Supplemental food, 3,972 grams.....	282.8	143.9	449.5	.....
	Total for 8 days.....	626.8	173.2	3,557.6	.....
	Average per day { Total nutrients.....	78.4	21.6	444.7	.....
90	Bread, 4,323 grams.....	200.0	2.4	2,439.3	.....
	Rice, cooked, 1,460 grams.....	48.3	.7	471.3	.....
	Soup, 4,708 grams.....	90.3	25.9	146.5	.....
	Supplemental food, 4,104 grams.....	290.8	141.0	429.5	.....
	Total for 8 days.....	629.4	170.0	3,486.6	.....
	Average per day { Total nutrients.....	78.7	21.3	435.8	.....
91	Bread, 4,424 grams.....	204.5	2.6	2,496.4	.....
	Rice, cooked, 1,453 grams.....	46.8	.5	470.3	.....
	Soup, 4,731 grams.....	90.8	26.0	143.4	.....
	Supplemental food, 3,966 grams.....	285.6	143.7	429.7	.....
	Total for 8 days.....	627.7	172.8	3,539.8	.....
	Average per day { Total nutrients.....	78.5	21.6	442.5	.....
92	Bread, 4,476 grams.....	206.9	2.5	2,514.5	.....
	Rice, cooked, 1,487 grams.....	49.4	.7	467.8	.....
	Soup, 3,916 grams.....	75.9	21.7	122.6	.....
	Supplemental food, 4,033 grams.....	287.1	144.5	415.8	.....
	Total for 8 days.....	619.3	169.4	3,520.7	.....
	Average per day { Total nutrients.....	77.4	21.2	440.1	.....
Average for 6 studies { Total nutrients.....		78.7	21.4	441.6	.....
Digestible nutrients.....		63.8	18.3	427.5	2,249

a See pages 160-163.

DIETARY STUDIES WITH MILITARY NURSES (Nos. 93 and 94).

These studies form part of an investigation conducted by G. Oi^a for the purpose of comparing a rice ration with a bread ration. The diet in the rice ration (study No. 93) consisted mainly of rice and fish, and in the bread ration (study No. 94) mainly of bread and meats, though both rations included some vegetables. The investigation included a study of the amounts of food eaten and of nutrients supplied and determinations of the digestibility of the nutrients of the ration. The digestion experiments (Nos. 70 and

^a Gun-i Gakko Gyofu (Arb. K. Japan. Militär-Ärztl. Lehranst.) [Bul. Army Med. Col.], Tokyo, 1892, No. 1 p. 111.

71) are given on pages 163 and 164; the statistics regarding quantities of nutrients and energy in the food consumed per subject per day are here summarized.

Each study continued twelve days, but the date of the investigation was not stated. The subjects of the studies were 10 military nurses, presumably adults, though no information was given regarding their ages or weights. Samples of the food materials were analyzed, but the results of the analyses were not reported.

TABLE 36.—Results of dietary studies Nos. 93 and 94.

Study No.	Kind of food.	Nutrients and energy per man per day.			
		Protein.	Fat.	Carbo-hydrates.	Fuel value.
93	<i>Army rice ration.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
	(Total nutrients.....)	113.0	55.1	460.1	.....
	(Digestible nutrients.....)	a 110.1	46.8	a 444.0	2,789
94	<i>Army bread ration.</i>				
	(Total nutrients.....)	84.7	20.1	626.0	.....
	(Digestible nutrients.....)	a 82.4	16.6	a 606.0	3,066

a See page 164.

DIETARY STUDIES WITH MARINES (No. 95).

This study was made by T. Honda,^a a navy surgeon, on board the training battle ship *Hi-ei*, which left Japan on September 20, 1891, and after visiting several ports in Oceania, Sulu, Manila, Hongkong, and elsewhere, returned to the home port on April 10, 1892. The voyage continued 204 days, of which 90 days were spent in different ports. The subjects of the study were 322 men—61 noncommissioned navy officers and 261 marines. The average weight of the officers at the beginning was 52.54 kilograms, and at the end of the voyage, 53.47 kilograms; and the corresponding weights for the marines were 57.33 and 58.60 kilograms.

The sanitary conditions were on the whole very good. In one of the ports malaria was very prevalent at the time the stop was made, and, in spite of strict precautions taken to prevent it, some of the marines were affected, though the number was stated to be very small. Five officers and four marines suffered from kakke, or beriberi, during the voyage, but the cases were of a light nature and of short duration.

Although the ship touched at ten ports during the voyage, in only four were fresh food materials obtainable. The crew was therefore obliged to depend mostly upon the ship's provisions throughout the voyage. Among the most important food materials consumed during the voyage were the following: Canned beef, consisting of boiled beef

^a Kaigun Iji Hokoku Saiyo (Rpt. Med. Bur. Imp. Navy), Tokyo, 1892, No. 21, p. 67; Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 8 (1894), p. 367.

and corned beef, both of foreign production; canned fish, largely salmon of native production; rice, all of home production; bread, largely foreign production; dried bread, partly home and partly foreign production; legumes, including both dried beans and soy beans and their preparations; fresh vegetables, including cabbages, cucumbers, onions, potatoes, radish, taro, turnips, yams, and others; dried vegetables, including edible fungi and ferns, taro stems and gourds, dried marine algæ, including *Ulopteryx pinnatifida*, *Cystophyllum fusiform*, *Laminaria* sp., and *Porphyra laciniata*.

No samples were analyzed; the percentage composition of each food material used was assumed from the results of previous analyses.

TABLE 37.—Results of dietary study No. 95.

Kinds and amounts of food consumed per man for 204 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Beef: Beef, 16,793 grams; beef, canned, 14,638 grams.....	30.4	26.3		
Pork, etc.: Bacon, 702 grams; lard, 1,358 grams.....	.9	6.9		
Fish: Fish, canned, 17,908 grams; dried bonito, 1,732 grams...	31.4	3.4		
Eggs, 742 grams.....	.5	.4		
Milk: Condensed milk, 375 grams.....	.2	.2	1.0	
Total animal food.....	63.4	37.2	1.0	
<i>Vegetable food.</i>				
Cereals: Bread, 31,234 grams; dry bread, 37,398 grams; rice, 67,304 grams; wheat flour, 7,624 grams; fu, roasted, 335 grams; vermicelli, 834 grams.....	61.0	7.8	477.9	
Sugar, 5,226 grams.....			23.8	
Legumes and their preparations: Legumes, 7,763 grams; miso, 2,602 grams; shoyu, 8,981 grams.....	15.3	5.6	15.9	
Vegetables: Algæ, 735 grams; pickles, 1,811 grams; sesame oil, 469 grams; fresh vegetables, 39,050 grams; dried vegetables, 6,562 grams.....	6.6	3.0	34.1	
Total vegetable food.....	82.9	16.4	551.7	
Total food.....	146.3	53.6	552.7	
(Total nutrients.....)	127.3	45.6	541.7	3,264
Condiments: Barley, roasted, 1,218 grams; mustard, 104 grams; pepper, 32 grams; tea, 612 grams; vinegar, 1,678 grams; table salt, 4,371 grams.....				

DIETARY STUDY WITH COAL MINERS (No. 96).

This study was made by F. Sekiba^a with men working in a coal mine at Yubari, Hokkaido. There were 250 miners in all, but whether the total number or only part of them were included in the study was not stated, and the length of the experimental period was not given in the original. The data reported showed only the average amounts of the different kinds of food eaten per man per day and the nutrients supplied. The amounts of food eaten were calculated from the account kept by the cook, and the amounts of nutrients were computed by use of known values for composition of

^aHokkaido Iji Kodankwai Geppo (Mo. Rpt. Hokkaido Med. Assoc.), Sapporo, 1893, No. 41, p. 23.

similar foods. The results of this study may therefore be less accurate than those in which all food materials eaten were weighed directly.

The miners worked in three shifts of eight hours each, the first shift from 6 a. m. to 2 p. m., the second from 2 p. m. to 10 p. m., and the third from 10 p. m. to 6 a. m. It was customary for the men in the last shift to take four meals during their period of work, while those in the other shifts ate three meals each.

The diet consisted of meat, fish, rice, and vegetables. Corned beef, salted salmon, and dried herring were used regularly. Fresh beef, pork, chicken, wild fowl and horse flesh were sometimes used, but the mine was situated so far from a market that it was difficult to obtain fresh food regularly, and the men had to depend largely upon preserved or canned foods and dried vegetables. Miso soup and vegetables, such as cabbage, radish and turnip, and marine algæ were regular articles of diet. At the last meal, that is, the one after the day's work was ended, the men usually had a small amount of sake. The estimated cost of the food per man per day was 12 to 14 sen (6 to 7 cents).

TABLE 38.—*Results of dietary study No. 96.*

Kinds and amounts of food consumed per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meat: Beef, 88 grams; pork, 87 grams.....	30.8	37.2		
Fish: Dried bonito, 87 grams.....	66.2	4.5		
Total animal food.....	97.0	41.7		
<i>Vegetable food.</i>				
Rice (cooked?), 1,260 grams.....	38.6	.7	401.3	
Legumes: Miso, 42 grams.....	5.5	2.5	6.4	
Vegetables: Algæ, 28 grams; radish, pickled, 60 grams.....	4.0	.2	15.1	
Total vegetable food.....	48.1	3.4	422.8	
Total food { Total nutrients.....	145.1	45.1	422.8	
Digestible nutrients.....	126.2	38.3	414.3	2,660

There appears to have been an error made in the original report in tabulating the data for rice. In discussing the data of the study the investigator stated that the amount of rice consumed per man per day was very large, and averaged 6.8 "go." According to an estimate by the compiler, 6.8 go would be equivalent to 875 grams of cleaned (uncooked) rice. In tabulating the statistics the investigator gave 1,260 grams as the quantity of rice per man per day, without specifying whether he meant cooked or uncooked rice. From the quantities of nutrients computed it would appear that cooked rice was meant. Apparently this is the amount of cooked rice calculated as equivalent to 6.8 go of uncooked rice. But 1,260 grams of cooked

rice is equivalent to about 550 grams of uncooked rice, which is considerably less than the quantity estimated by the compiler from 6.8 go. According to the larger estimate for the quantity of rice, the amounts of nutrients in the table above should be increased by about 19 grams of protein, 1 gram of fat, and 241 grams of carbohydrates, and the fuel value by 1,050 calories, making the totals 164.1 grams of protein, 46.1 grams of fat, 642.8 grams of carbohydrates, and 3,710 calories. A communication regarding this apparent error was addressed to the investigator, but no reply was received.

DIETARY STUDIES WITH MILITARY PATIENTS (Nos. 97 and 98).

These studies were made in a military hospital at Jumamoto, by Fuchizaki and Takenouchi, under the direction of H. Horiguchi,^a and reported by the latter. The number of persons included in the studies was not given. The studies began October 23, 1893, and continued seven days.

In study No. 97 a rice-barley diet was used, i. e., the principal food consisted of a mixture of rice and cracked barley cooked together. The supplemental food consisted of beef, chicken, fish, bean sprouts, tofu, and other preparations of soy bean, vegetables, and pickles. The average cost per man per day, 10 sen (5 cents), was estimated from the weights and cost of food materials used for cooking and the number of persons served at each meal.

To calculate the amounts of nutrients in the food eaten the cooked food was weighed for each person. Samples of the cooked food were obtained by the investigator and analyzed, the sample for the supplemental food being a composite of portions of each kind of food used each day. Daily composite samples of the rice-barley mixture were also obtained and the water content determined. Complete analysis of the rice-barley mixture was made of a composite for seven days. The nitrogen-free extract was determined directly by hydrolyzing with acid and determining the amount of sugar thus produced. The remainder of the determinations were made in the usual way. The results of the analyses were not given in the original in such form that they can be quoted.

In study No. 98 rice gruel was used for patients who required a soft and easily digested food. The whole diet consisted of rice gruel, eggs, shoyu, and pickled plums. The rice gruel and eggs were analyzed. The method of study was the same as in No. 97. The cost per man per day was 11.5 sen (6 cents).

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1894, No. 68, p. 147.

TABLE 39.—Results of dietary studies Nos. 97 and 98.

Kinds and amounts of food per man for 7 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Study No. 97.</i>				
Rice-barley mixture, cooked, 9,877 grams.....	<i>Grams.</i> 37.3	<i>Grams.</i> 7.2	<i>Grams.</i> 399.5	<i>Calories.</i>
Supplemental food, 4,397 grams.....	31.5	9.7	39.4	.....
Total food { Total nutrients.....	68.8	16.9	438.9	.....
Digestible nutrients.....	52.3	14.4	425.7	2,169
<i>Study No. 98.</i>				
Eggs, 1,456 grams.....	26.3	26.1	7.6	.....
Rice gruel, 13,600 grams.....	14.2	1.1	194.2	.....
Shoyu, 483 grams.....	5.8	.....	3.5	.....
Plums, pickled, 315 grams.....	.2	.....	6.1	.....
Total food { Total nutrients.....	46.5	27.2	211.4	.....
Digestible nutrients.....	40.5	23.1	207.2	1,266

DIETARY STUDIES WITH NATIVE FORMOSANS (No. 99).

This study was made by S. Onda.^a It began with supper March 2, and ended with breakfast March 5, 1896. The subjects were three healthy natives employed as day laborers at the military hospital at Daihoku, Formosa. They were respectively 22, 31, and 38 years old, and 60.9, 55, and 54.8 kilograms in weight. To insure the reliability of the study the subjects were under constant observation throughout the whole period.

The cooked rice used during the study was analyzed separately, while a composite sample of the rest of the food was obtained and analyzed. The composite of the accessory food for the first day was accidentally lost, and the data given in the original cover the food eaten for two days only. The results of the analyses were not available for this compilation.

TABLE 40.—Results of dietary study No. 99.

Kinds and amounts of food consumed by 3 persons for 2 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
Rice, cooked, 5,350 grams.....	<i>Grams.</i> 37.3	<i>Grams.</i> 5.7	<i>Grams.</i> 399.5	<i>Calories.</i>
Supplemental food: Salted fish, 22 grams; melon, salted, 68 grams; spinach, 122 grams; ginger, salted, 75 grams; greens, 448 grams.....	10.7	3.2	17.1	.....
Total food { Total nutrients.....	48.0	8.9	416.6	.....
Digestible nutrients.....	37.4	7.3	408.3	1,948

The total quantity of protein and energy in the diet of these subjects was remarkably small. To what extent this may be considered as representative of the diet of native Formosans it is impossible to say.

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1896, No. 75, p. 525.

During four days preceding the study, and during the three days of the study, urine was collected and a composite sample for seven days was made for each subject, acetic acid being used as a preservative. The nitrogen was determined by the Kjeldahl method, phosphoric acid by precipitation with ammonium molybdate, the sulphur as barium sulphate, and chlorin as silver chlorid. The average amounts per day were as follows:

TABLE 41.—Average composition of urine in dietary study No. 99.

Subject.	Nitrogen.	Phosphoric acid.	Sulphur.	Chlorin.
	Grams.	Grams.	Grams.	Grams.
No. 1.....	6.81	1.28	1.96	4.12
No. 2.....	7.59	1.51	1.94	2.92
No. 3.....	6.40	.74	1.56	2.00
Average.....	6.93	1.18	1.82	3.01

DIETARY STUDY WITH A MILITARY COLONIST (No. 100).

This study was made by S. Nagase,^a an army surgeon, with a military colonist at Hokkaido. The military colonists do not live in barracks, but at their own homes. They have a military drill at certain fixed times, but the remainder of the time they engage in farming. The object of this study was to determine the amounts of nutrients in the diet consumed by healthy military colonists of the average standard of living, and the subject was very carefully selected with the advice of officers in charge of the district.

The study began January 7, 1896, and continued seven days. The subject, I. Y., who lived at Fukagawa, Province of Uryu, Hokkaido, was a healthy man 20 years old, weighing 59.9 kilograms at the beginning of the study and 57.9 kilograms at the end. He was accustomed to a very simple diet and was a total abstainer from all alcoholic beverages. The family consisted of 6 persons, but the study was restricted to the food consumed by the subject alone. Until the 28th of December, just preceding the time of the study, the subject had been occupied four hours daily with military drill, but on only one day during the study, namely, two hours on January 10, was he thus engaged. He spent some time during the period of the study chopping wood, but the total amount of physical exercise for the whole period was very small.

The diet consisted of cereals and vegetables; rice, millet, dried bracken (*Pteridium aquilinum*), miso, shoyu, potatoes, radishes, turnips, and pickled radishes being the different kinds of food materials used. Each cooked food material used by the subject was weighed

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1896, No. 76, p. 650.

before each meal, and the waste was also weighed. The experimenter obtained samples of all the raw materials used in the study, and cooked 10 to 100 grams of each, according to the nature of the material, in the same way as was done by the family, and determined the increase in weight. This gave experimental data for the calculation of the amounts of nutrients in the diet from the known chemical composition of the raw materials. No detailed data regarding the amounts of the different foods consumed are given in the original report. The results of the study as reported simply show the average daily quantities of nutrients in the food actually eaten by the subject, and these data are here given.

TABLE 42.—*Results of dietary study No. 100.*

Kind of food.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates	Fuel value.
Mixed vegetable diet:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Total nutrients.....	59.3	7.7	594.4	.....
Digestible nutrients.....	46.3	6.1	582.5	2,703

Though this subject belonged to a class that is really a part of the army, he lived at his own home, as explained above, and did not receive the army ration. His diet was rather more like that of people in the rural districts in Japan. In fact this is the only study of the diet of people of that class found on record. Kajita made a study of the amounts of nitrogen in the urine excreted by three farmers, and his results are interesting in comparison here. One subject was 39 years old and weighed 50.3 kilograms, another was 37 years old and weighed 52 kilograms, and the third was 59 years old and weighed 48 kilograms. During five days subject No. 1 excreted 11.48 grams nitrogen per day; with subjects Nos. 2 and 3 the experimental period covered three days, the average amounts of nitrogen excreted being 10.98 and 10.18 grams per day, respectively.

This would be equivalent, on the average for the three, to about 78 grams of protein per day, which is somewhat larger than the amount in the diet of the military colonist.

DIETARY STUDY WITH PRISONERS (No. 101).

This study, which was made by the Metropolitan Police Board,^a Tokyo, in the police prison, and reported by T. Noda, began January 1, 1897, and continued seven days. The number of prisoners during the period of the study was 1,011, equivalent to 1 man 70,077 days.

The principal material in the ration consisted of a rice-barley

^a Dai Nippon Shiritsu Eiseikwai Zasshi (Jour. Sanit. Soc. Japan), Tokyo, 1898, No. 182, p. 121.

mixture in the proportion of 4 parts of the former to 6 of the latter. The quantity of this mixture allowed per man per day was 4 "go" (the Japanese measure "go" is equivalent to 182 cubic centimeters). In addition to this, supplemental food to the value of 1 sen (0.5 cent) per man per day was allowed, and in these studies the quantity of such food used cost exactly that amount. It was also customary in the prison to give once every three days a quantity of fish costing 1 sen (0.5 cent) for each man. During the seven days of the study this extra supply of fish was served twice, but it was not included in the table giving the results of the study.

It was stated that in the year following this study the allowance for supplemental food was increased in order to improve the diet, but the amount of increase was not stated.

TABLE 43.—Results of dietary study No. 101.

Kinds and amounts ^a of food for 1,011 persons for 7 days.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
meats: Beef, 3,822 grams.....	Grams. 0.1	Grams. 0.1	Grams.	Calories.
Lard, 808 grams.....		.1		
Fish: Shellfish, 3,822 grams.....	.1			
Total animal food.....	.2	.2		
<i>Vegetable food.</i>				
Cereals: Rice-barley mixture, 3,637,578 grams.....	41.9	5.4	375.8	
Legumes and their preparations: Soy bean, 11,465 grams; miso, 366,872 grams; shoyu, 159,865 grams; tofu, fried, 26,751 grams.....	11.0	4.2	7.6	
Vegetables: Algae (<i>Uloperyx pinnatifida</i>) 11,465 grams; <i>Lami- naria</i> spp., 38,216 grams; <i>Cystophyllum fusiiform</i> , 11,465 grams; greens, 156,685 grams; onions, 7,643 grams; pota- toes, 122,290 grams; plum, pickled, 53,502 grams; radish, pickled, 321,013 grams; radish, dried, 38,216 grams; sesa- mum, 26,751 grams.....	3.1	.8	15.9	
Total vegetable food.....	56.0	10.4	399.3	
Total food { Total nutrients.....	56.2	10.6	399.3	
Digestible nutrients.....	42.7	8.7	387.3	1,896

^a In general, the weight was given in the Japanese unit "momme." In recalculating, 1 "momme" was taken as equivalent to 3.78 grams. The amount of rice-barley mixture per man per day was given as 4 "go" in volume. Its corresponding weight was not given. From the best available data it was assumed that 4 "go" of the mixture would weigh 514 grams.

DIETARY STUDY WITH AN ARMY SURGEON (No. 102).

This study was made by S. Nagao,^a an army surgeon, as part of an investigation to determine both the total amounts and the digestibility of the nutrients in the ration of the provision corps at Kanazawa. The details of the digestion experiment (No. 101) are given on page 174.

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1899, No. 103, p. 493.

The subject was the investigator himself, who weighed 54 kilograms, and during the period of the study, four days (date not given), took exercise as similar as possible to that of the soldiers.

The principal item in the diet was a rice-barley mixture composed of 7 parts of rice to 3 parts of barley cooked together; but in addition to this the diet included beef, cod, flounder, kamaboko, eggs, miso, shoyu, tofu, edible burdock, carrots, konnyaku, lotus root, onions, sweet potatoes, taro, radishes, and pickles. Two portions of the cooked foods allowed to each soldier were carefully selected and weighed at each meal, one portion being eaten by the subject and the other made into a composite sample for analysis.

TABLE 44.—*Results of dietary study No. 102.*

Kind of food.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
Army ration with barley:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Total nutrients.....	92.0	13.8	521.3	.....
Digestible nutrients.....	^a 79.3	11.7	^a 502.0	2,567

^a See page 174.

STUDIES OF NAVY RATIONS. PEACE FOOTING (Nos. 103-121).

Studies Nos. 103-119. Former ration allowance of marines.—The data here summarized as studies Nos. 103-119 are based on the estimates of the amounts of nutrients in the allowance of marines in the navy during seventeen years (1884-1900) which were reported by the medical bureau of the navy.^a No details of the methods of study and calculation were given in the report. The amounts of nutrients were given per man per day, and these were evidently calculated from the amounts of food purchased. If so, the results of course do not show the amounts of nutrients in food actually eaten, for some allowance must be made for waste. Since there are no data regarding the quantities of waste, the results given are to be considered simply as a general indication of the food consumption. The number of persons given in the table includes those whose weights were actually recorded. The figures are believed, however, to represent, at least approximately, the total number of marines during the years indicated.

^a Kaigun Iji Hokoku Saiyo (Rpt. Med. Bur. Imp. Navy), Tokyo, 1892, No. 21, p. 67; Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 8 (1894), p. 367; Kaigunsho Imukyoku Hokoku (Rpt. Med. Bur. Imp. Navy), 15 (1900), p. 90.

TABLE 45.—*Japanese navy rations.*

Study No.	Date.	Marines.		Nutrients and energy per man per day.						
		Average weight.	Number of persons.	Total.			Digestible. ^a			Fuel value.
				Protein.	Fat.	Carbo-hydrates.	Protein.	Fat.	Carbo-hydrates.	
		<i>Kilos.</i>		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Cals.</i>
103.....	1884	54.6	4,308	196	44	773	171	37	758	4,285
104.....	1885	54.6	5,329	197	45	795	171	38	779	4,390
105.....	1886	55.2	6,649	213	48	768	185	41	753	4,360
106.....	1887	55.9	7,932	186	48	695	162	41	681	3,960
107.....	1888	56.3	8,728	182	44	665	158	37	652	3,790
108.....	1889	56.7	8,586	193	45	718	168	38	704	4,055
109.....	b 1890	56.4	8,433	159	29	553	138	25	542	3,120
110.....	b 1891	57.0	9,642	140	25	530	122	21	519	2,920
111.....	b 1892	57.2	9,480	145	28	543	126	24	532	3,015
112.....	b 1893	57.9	8,103	148	28	549	129	24	538	3,055
113.....	b 1894	58.2	9,066	158	30	603	137	26	591	3,330
114.....	b 1895	58.5	11,957	157	30	578	137	26	566	3,220
115.....	b 1896	58.1	11,759	148	29	546	129	25	535	3,045
116.....	b 1897	58.6	14,636	146	28	541	127	24	530	3,010
117.....	b 1898	58.3	17,747	170	30	538	148	26	527	3,110
118.....	b 1899	58.4	18,927	178	35	600	155	30	588	3,435
119.....	1900	57.9	22,530	183	37	593	159	31	581	3,440

^a Calculated by use of the factors given on page 206.^b In these years the allowance of food issued was slightly reduced, and a small amount of money was granted for the purchase of extra food at the discretion of the individual.

As is explained elsewhere (pp. 14 and 59) a food-supply act was passed in 1884, the object of which was to increase the amount of protein in the navy dietary. A large part of the rice was to be replaced by bread, and meats were to be used liberally. The experience during the first year that this ration was tried indicated that bread and meats could not be advantageously substituted immediately for the rice, because most of the marines were unaccustomed to those food materials, consequently a modification of the ration was introduced in 1885 whereby a rice-barley mixture was adopted in place of the bread. Equal parts of rice and cracked barley were to be cooked. Barley was considered at that time as a better article of food than rice, on account of its higher protein content, but later investigations showed that the digestibility of the nutrients of barley was small. In 1886 an effort was again made to substitute bread for the rice-barley mixture. In 1890 the ration allowance was reduced by one-fifth and an amount of money equivalent to the cost of the reduction in diet was given each marine with which to buy accessory food according to his own choice. In 1898 the reduction was made one-tenth instead of one-fifth as in previous years. The amounts of accessory food thus bought and eaten could not be estimated, and consequently are not included in the results in the table above. In 1900 the cash allowance was abolished and a new ration, which is described on page 100, was adopted.

The following statistics are interesting, in so far as they show the sanitary conditions of the marines following the improvement in the diet. During the six years 1878-1883, inclusive, out of a total number of 29,321 marines 9,516, or 32.5 per cent, suffered from

kakke, or beriberi. During the six years after the new ration was adopted the total number of such patients was but 765 out of a total of 48,275 marines, or only 1.6 per cent. This is a very striking contrast with the percentage of patients during the preceding years. The decrease is more surprising when it is observed that of the 764 patients 718 cases occurred during the year 1884 when the new ration was first adopted. In the following year, 1885, there were but 41 cases, and in 1886 only 3 cases were recorded; in the next three years, 1887–1889, there were altogether only 3 cases known. The number of marines suffering from other diseases was also very materially decreased.

It should be especially noted that here no attempt has been made to indicate the cause of beriberi or the relation between the disease and the diet. The statistics are interesting chiefly as an indication of some of the reasons why the problem of nutrition attracted a great deal of attention in the navy.

Studies Nos. 120 and 121. Revised navy ration allowance.—A revision of the food supply act of the navy was passed May 29, 1900, and was in force at the time of preparing the present bulletin. The following tables show the kinds and amounts of food and the quantities of nutrients and energy per man per day in the navy ration allowance provided according to this revised food supply act.^a Study No. 120 is the allowance at sea, and No. 121 is the allowance while on land or in the harbor.

Fresh meats included beef and pork; preserved meats included canned, boiled, and roast beef, etc.; preserved fish included canned salmon, trout, sardine, etc.

TABLE 46.—*Navy ration allowance at sea.*

Kinds and amounts of food per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats: Meats, preserved, 150 grams.....	30.3	8.1		
Fish: Fish, preserved, 150 grams.....	32.4	5.5		
Fats, 5.4 grams.....		4.9		
Total animal food.....	62.7	18.5		
<i>Vegetable food.</i>				
Cereals: Biscuit, ^b 188 grams; rice, 375 grams; barley, cracked, 131 grams; wheat flour, 8 grams.....	69.1	6.5	506.8	
Sugar, 38 grams.....			36.3	
Legumes and their preparations: Legumes, 13 grams; shoyu, 74 grams.....	6.8	.9	3.6	
Vegetables: Dried vegetables, 75 grams; sesame oil, 2.1 grams.....	7.4	2.7	39.3	
Total vegetable food.....	83.3	10.1	586.0	
Total food { Total nutrients.....	146.0	28.6	586.0	
Digestible nutrients.....	127.0	24.3	574.3	
Condiments: Barley, roasted, 4 grams; tea, 2 grams; table salt, 8 grams; vinegar, 7 grams.....				3,199

^a Official correspondence of the Medical Bureau, Imperial Navy, Japan.

^b Crackers, probably pilot bread.

TABLE 47.—*Navy ration allowance on land or in harbor.*

Kinds and amounts of food per man per day.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Animal food.</i>				
Meats: Meats, preserved, 21 grams; meats, fresh, 154 grams ..	Grams. 35.2	Grams. 9.4	Grams.	Calories.
Fish: Fish, preserved, 20 grams; fish, fresh, 103 grams	26.7	4.5	.....	.....
Fats, 5.4 grams .....	.....	4.9	.....	.....
Total animal food	61.9	18.8	.....	.....
<i>Vegetable food.</i>				
Cereals: Bread, 209 grams; biscuits, ^a 27 grams; rice, 375 grams; barley, cracked, 131 grams; wheat flour, 8 grams ..	64.4	5.7	500.2	.....
Sugar, 38 grams .....	.....	.....	36.3	.....
Legumes and their preparations: Legumes, 13 grams; shoyu, 38 grams	6.8	.9	3.6	.....
Vegetables, 450 grams; sesame oil, 2.1 grams	21.9	7.3	53.4	.....
Total vegetable food	93.1	13.9	593.5	.....
Total food { Total nutrients	155.0	32.7	593.5	.....
{ Digestible nutrients	134.9	27.8	581.6	3,298
Condiments: Barley, roasted, 4 grams; tea, 2 grams; table salt, 8 grams; vinegar, 7 grams .....	.....	.....	.....	.....

^a Crackers, probably pilot bread.**DIETARY EXPERIMENTS.**

As previously stated, a number of investigations of food consumption were made for some specific purpose, the object being in most cases to study the amount of protein required daily. In a very few cases the subjects were allowed free choice in diet, at least as regards amount eaten, and in these the data are comparable with those of regular dietary studies; but in the large majority of cases the diet was prescribed, and these are more in the nature of feeding experiments than of dietary studies. The investigations of this nature are here brought together as dietary experiments.

In each of these the digestibility of the protein of the diet was determined, but not of the other nutrients. The data regarding digestibility are given in Tables 87 and 88, pages 185 and 186.

EXPERIMENTS WITH A PHYSICIAN (Nos. 27-30).

These studies were made by M. Kumagawa^a in the Chemical Laboratory of the Pathological Institute in Berlin in 1887-88. The object was to compare the value of a mixed diet with that of a vegetable diet, with special reference to the amount of protein required by man. In each study the digestibility of the protein of the diet was determined. (See p. 184.)

The subject was the investigator himself, a physician, 27 years old, 154 centimeters in height, and weighing 48 kilograms. During the period of the investigation he was occupied in the laboratory

^a Arch. Path. Anat. u. Physiol. [Virchow], 116 (1889), p. 370; Tokyo Iji Shinshi (New Med. Jour. Tokyo), 1889, No. 595, p. 1467.

from five to six hours a day, in addition to the time spent in weighing and cooking the foods which he used.

At the time the investigation began the subject had been living in Europe more than three years, and had become accustomed to the ordinary European diet. A preliminary experiment was made to determine the amount of protein he ordinarily consumed in such a diet. Since he took most of his meals at a restaurant, it was impracticable to weigh accurately the amounts of foods consumed. He therefore collected his urine and feces during thirty-five days, and from the amount of nitrogen determined in these he computed that his average daily consumption of protein was 70.4 grams.

The diet during the experiments, however, was intended to be more typically Japanese in character. Miso and shoyu, which form a necessary part of a Japanese diet, were obtained in Berlin, but they had been imported from Japan. The other materials used were those commonly found in German markets. The beef, fish, eggs, and onions used in experiments Nos. 27 and 28 were not analyzed, their composition being assumed from previous analyses. The other foods were analyzed, the data, both those determined and those assumed, being included in Table 6. Nitrogen was determined by the Kjeldahl method.

Experiment No. 27.—The experiment began December 11, 1887, immediately following the preliminary observations, and continued thirteen days. The average air temperature during the period was 2° C. The subject weighed 48.7 kilograms at the beginning of the study and 49.2 kilograms at the end.

In selecting his food materials during this study the investigator took special pains to choose a diet which would render possible accurate determinations of the nutrients and yet at the same time retain all the essential characters of the mixed diet prevalent among the middle and higher classes in Japan. The kinds and amounts of food eaten at the different meals were regulated entirely by choice and appetite. The data regarding the nutrients and energy in the diet in this experiment are therefore strictly comparable with those obtained in regular dietary studies. Three meals were eaten each day—breakfast at about 9 a. m., consisting of cooked rice, miso soup with turnip as the ingredient, eggs, with shoyu, salted turnip, and a weak infusion of tea; dinner at 2 p. m., consisting of rice, beef or fish, salted turnip, and tea infusion; supper at 8 to 9 p. m., about the same as dinner. One or two bottles of beer consumed daily.

Experiment No. 28.—In this experiment the amount of food consumed was limited, the object being to determine how low the quantity of protein and energy could be reduced without undesirable effects upon bodily conditions. The study immediately followed study No. 27, beginning December 24 and ending December 28, 1887,

thus covering five days. The average air temperature during this experiment was -4.8°C . The subject weighed at the beginning of the experiment 48.6 kilograms and at the end 48 kilograms.

Experiment No. 29.—This study immediately followed the one preceding, beginning December 29, 1887, and continuing five days. The average air temperature during the period was -5.5°C . The subject weighed 48.6 kilograms at the beginning and 48.3 kilograms at the end of the experiment. The diet consisted of rice and vegetables, the kinds and amounts of food eaten being the same each day. The total quantity of food was so regulated that nearly the same quantity of energy was supplied as by the diet of the preceding study. Nitrogen was determined in all the foods.

Experiment No. 30.—This study, immediately following study No. 29, began January 3, 1888, and continued nine days. The average air temperature was 1.3°C . The plan of the experiment and the diet were the same as in experiment No. 29, except that the amounts of food eaten were larger. Nitrogen was determined in all food materials. The subject, though he had never before lived on a vegetable diet, felt as well as usual throughout the whole period. No disturbance of digestive functions nor any difference in his capacity for work was observed. The subject weighed 48.5 kilograms at the beginning and 48.9 kilograms at the end of the study.

The data regarding the kinds and amounts of food consumed and the nutrients and energy per day in the diets of these four studies are given in the following table:

TABLE 48.—Results of dietary experiments Nos. 27–30.

Kinds and amounts of food consumed.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel values.
<i>Experiment No. 27.—One person 13 days.</i>				
ANIMAL FOOD.				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats: Beef (15), 1,322 grams.....	20.9	1.8	.....	.....
Fish: Pike (25a), 627 grams.....	8.8	.2	.....	.....
Eggs: Raw (1), 1,233 grams.....	11.9	11.5	.....	.....
Total animal food.....	41.6	a 13.5	.....	.....
VEGETABLE FOOD.				
Cereal: Rice (41), 6,300 grams.....	30.0	1.6	362.5	.....
Sugar, 81.5 grams.....	.....	.....	6.3	.....
Legumes and their preparations: Miso (78), 325 grams; shoyu (86), 743 grams.....	9.6	.....	9.4	.....
Vegetables: Onions (106), 1,927 grams; turnips (116), 3,064 grams.....	3.7	.6	34.4	.....
Total vegetable food.....	43.3	2.2	a 412.6	.....
Beverages: Beer (125), 11,045 cubic centimeters, tea decoction (127), 15,045 cubic centimeters.....	5.4	.....	75.9	.....
Total food { Total nutrients.....	90.3	15.7	488.5	.....
{ Digestible nutrients.....	b 76.3	13.3	478.7	2,471

a With the consent of the original investigator, an error found in the reported data was rectified.

b See p. 185.

TABLE 48.—Results of dietary experiments Nos. 27–30—Continued.

Kinds and amounts of food consumed.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel values.
<i>Experiment No. 28.—One person 5 days.</i>				
ANIMAL FOOD.				
Fish: Pike (25), 422 grams.....	Grams. 15.5	Grams. 0.4	Grams.	Calories.
VEGETABLE FOOD.				
Cereal: Rice (49), 2,250 grams.....	27.8	1.5	336.6	
Legumes and their preparations: Miso (78), 284 grams; shoyu (86), 80 cubic centimeters.....	7.9		11.2	
Vegetables: Turnips (116), 1,354 grams.....	1.8	.5	19.9	
Total vegetable food.....	37.5	2.0	367.7	
Beverages: Beer (125), 3,940 cubic centimeters; tea decoction (127), 5,940 cubic centimeters.....	5.0		74.0	
Total food/Total nutrients.....	58.0	2.4	441.7	
Digestible nutrients.....	a 46.8	2.0	432.9	2,043
<i>Experiment No. 29.—One person 5 days.</i>				
VEGETABLE FOOD. ^b				
Cereal: Rice (49), 450 grams.....	27.8	1.5	336.6	
Legumes and their preparations: Miso (78), 80 grams; shoyu (86), 10 cubic centimeters.....	9.8		15.3	
Vegetables: Turnips (116), 250 grams.....	1.6	.4	18.4	
Total vegetable food.....	39.2	1.9	370.3	
Beverages: Beer (125) 800 cubic centimeters; tea decoction (127), 1,000 cubic centimeters.....	5.0		71.4	
Total food/Total nutrients.....	44.2	1.9	441.7	
Digestible nutrients.....	a 33.8	1.6	432.9	1,982
<i>Experiment No. 30.—One person 9 days.</i>				
VEGETABLE FOOD.				
Cereal: Rice (49), 5,400 grams.....	37.5	2.0	448.8	
Sugar, 250 grams.....			27.7	
Legumes and their preparations: Miso (78), 900 grams; shoyu (86), 90 cubic centimeters.....	12.1		19.1	
Vegetable: Turnips (116), 2,700 grams.....	1.9	.5	c 22.1	
Total vegetable food.....	51.5	2.5	517.7	
Beverages: Beer (125), 5,350 cubic centimeters; tea decoction (127), 5,250 cubic centimeters.....	3.2		c 53.1	
Total food/Total nutrients.....	54.7	2.5	570.8	
Digestible nutrients.....	a 42.0	2.1	559.4	2,584

^a See page 185.^b The amounts of foods per man per day.^c With the consent of the original investigator, errors found in these figures were rectified and the corrected figures are here used.

It is interesting to note that in experiment No. 27 the amount of protein in the diet, which was intended to be typically Japanese, was 20 grams more than the subject estimated that he had been getting in the diet which was European in character, although in both cases there was free choice as regards the kinds and amounts of food eaten. In this experiment the subject maintained nitrogen equilibrium, with food supplying 90.3 grams of protein and having a fuel value of 2,470 calories of energy.

Neither in experiment No. 28, upon a diet supplying 58 grams of protein and having a fuel value of 2,043 calories, nor in experiment No. 29, with a diet furnishing 44.2 grams of protein and having a fuel value of 1,982 calories, could the subject establish nitrogen equilibrium during the experimental period. In experiment No. 30, however, he gained nitrogen throughout the total period on a diet furnishing 54.7 grams of protein and having a fuel value of 2,555 calories of energy per day. The author ascribes the cause of loss of nitrogen in experiments Nos. 28 and 29 to an insufficient amount of energy supplied by the diet and not to the deficiency of protein. His conclusions may be summarized as follows:

It is only essential that the diet shall furnish the organism with the necessary amount of energy, and except for a small part of the protein it is immaterial what sort of nutrients supply this energy.

A grown man can exist and even store up nitrogen upon a daily diet that contains less than the amount of nitrogen excreted during hunger, provided a sufficient amount of energy is supplied to the body in the form of fat or carbohydrates.

EXPERIMENTS WITH PROFESSIONAL MEN (Nos. 35-42).

These studies were made by S. Amaya and N. Kirisawa, in the Medical College at Sendai, in 1890 and 1891, with especial reference to the amount of protein required by man. In each case the digestibility of the protein of the diet was determined (see p. 184).

The investigators themselves were the subjects of the studies. S. A. was a physician, 30 years old, 154 centimeters in height, engaged eight to nine hours a day in lecturing and in laboratory work. N. K. was an assistant in the medical department, 20 years old and 155 centimeters in height, engaged in laboratory work eight to nine hours a day.

The food was weighed separately at each meal before cooking, except in study No. 38, when the cooked food was weighed. Refuse was removed before weighing and there was no waste. Rice, miso, and shoyu, which were used in all the experiments, were bought in quantities sufficient to last during all the experimental days. Each food material was well mixed and sampled and then kept in a tightly closed vessel. Nitrogen in these foods, as well as in beef, fish, and sake, was determined by the Kjeldahl method, the results of the determinations being included in Table 6.

Experiment No. 35.—The experiment^a began December 5, 1890, and continued ten days. The subject, N. K., weighed at the beginning of the period 43.1 kilograms and at the end 42.8 kilograms. A mixed diet was eaten, beef, fish, and eggs being regularly used. In the selection of foods care was taken that the regular dietary of the

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 5 (1891), p. 1156.

subject would be represented. The nitrogen was determined in beef, rice, miso, and shoyu, but the fat and carbohydrates in these foods were computed and the composition of the other foods used was estimated from previous analyses.

The subject gained nitrogen on a diet supplying 84 grams of protein and having a fuel value of 2,090 calories.

Experiment No. 36.—This experiment^a began February 20, 1891, and was continued seven days, the average air temperature being 7° C. The subject, S. A., weighed at the beginning of the period 49.5 kilograms and the same at the end. A mixed diet of animal and vegetable food was eaten, beef, eggs, and fish being used regularly. Sake and tea infusion were used every day as beverages. The kinds and amounts of foods used in this experiment were regulated, upon careful consideration of the previous dietary habits of the subject, in such a way that the diet would be typical of that to which he had been accustomed. To determine the amount of nitrogen contained in his ordinary diet the urine had been collected during seven days, November 24 to 30, 1890, and the amount of nitrogen in it determined. The diet during that period had consisted of rice, miso soup, tofu, vegetables, and pickles, together with beef, fish, and eggs. A small quantity of sake was also used every evening. The daily excretion of nitrogen in the urine was found to average 12 grams, corresponding to 75 grams of protein.

Nitrogen was determined in samples of the beef, salted salmon, rice, miso, and shoyu used during the experiment. The amounts of fats and carbohydrates in these foods and the total nutrients in the other food materials used were computed by means of average figures for percentage composition, which are included in Table 6.

During the experimental period the subject gained nitrogen on a diet supplying 79 grams of protein and having a fuel value of 2,200 calories of energy per day.

Experiments Nos. 37 and 37a.—This experiment^b was divided into two periods, each of which is numbered separately, the first period, experiment No. 37, extending from January 26 to February 4, inclusive; and the second period, experiment No. 37a, from February 5 to February 10, inclusive. The average air temperature during both periods was 0° C. The subject, N. K., weighed at the beginning of the experiment 42.9 kilograms, at the end of the first period 42.8 kilograms, and at the end of the second period 43.2 kilograms.

The subject used a mixed diet in which salted fish was included. People of means in districts remote from the seashore use considerable quantities of salted fish, and this diet was so arranged as to be representative of the diet of this class of people. Salted salmon,

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 5 (1891) p. 1195.

^b Ibid., p. 1329.

which is used extensively in districts near Sendai, was the fish used in the experiments. Refuse was carefully removed and only the edible portion of the fish was weighed and used. Nitrogen was determined in salmon, rice, miso, and shoyu.

In both periods the kinds of food and the amounts of protein per day were exactly the same. The difference between the diets in the two periods was in the amount of carbohydrates, 38 grams more carbohydrates, supplying 150 calories more energy, being used in the second period.

In both periods the subject gained nitrogen on diets supplying 73 grams of protein, having a fuel value of 2,030 calories in the first period and 2,180 calories in the second period.

Experiment No. 38.—The experiment^a began December 18, 1890, and continued ten days. The average air temperature was 6° C. The subject, N. K., weighed at the beginning of the experiment 43 kilograms and at the end 42.7 kilograms.

The food consisted of a vegetable diet containing legumes and their preparations. Nitrogen was determined in a daily composite sample, including all the cooked foods except rice, prepared by combining one-tenth of the amount by weight of each cooked food eaten. The sample was well mixed, evaporated on a water bath, and finally dried at 100–110° C. Nitrogen in rice was determined separately. The percentage composition of the composite samples was not given in the original.

During the experiment the subject gained nitrogen while living on a vegetable diet supplying 83 grams of protein and having a fuel value of 2,305 calories per day.

Experiment No. 39.—This experiment^b began January 14, 1891, and continued five days. The subject, N. K., weighed at the beginning of the period 43.9 kilograms and at the end 43.3 kilograms. The object was to determine to what extent the quantity of protein in the diet might be reduced without disturbing the balance of nitrogen in the body. For this purpose a simple vegetable diet was used, the amount of food eaten being limited, and the same for each day of the experiment. Nitrogen was determined in rice, miso, and shoyu. The composition of other foods was estimated from results of previous analyses of similar materials.

During this experiment the subject could not maintain nitrogen equilibrium on a diet containing 48 grams of protein and having a fuel value of 1,825 calories of energy per day.

Experiment No. 40.—This experiment^b began June 12, 1891, and continued seven days, but was preceded by three days in which the subject ate the same kinds and amounts of food as during the experi-

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 5 (1891) p. 1389.

^b Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 6 (1892), p. 82.

ment. The average air temperature during the period was 17° C. The object of the experiment was to determine whether the cause of failure to establish a nitrogen balance in the previous experiment (No. 39) was due to a deficiency in the amount of nitrogen or in the amount of energy supplied in the food.

The subject, N. K., weighed at the beginning of the period 42.4 kilograms and at the end 42.3 kilograms. The diet during the experiment was of the same nature as that in experiment No. 39, and the daily menu was so arranged that the amount of protein in the diet was nearly the same as in that experiment, but the amount of energy furnished was much larger. Nitrogen was determined in rice, miso, and shoyu; the composition of tofu and of pickled radish was assumed.

During this experiment the subject gained a trifle in nitrogen upon a diet furnishing 52 grams of protein and having a fuel value of 2,200 calories of energy per day.

Experiment No. 41.—This experiment^a began March 14, 1891, and continued eight days. The average air temperature was 9° C. The subject, S. A., weighed 49.6 kilograms at the beginning and the same at the end. The diet consisted of vegetable foods. The amount of food eaten was limited, and was the same each day throughout the experiment. Nitrogen was determined in rice, miso, and shoyu, but the composition of the other foods was estimated.

The object of this experiment was the same as that of experiment No. 39. Although the diet supplied 50 grams of protein and had a fuel value of 2,120 calories of energy per day, the subject could not maintain nitrogen equilibrium.

Experiment No. 42.—This experiment^a began June 12, 1891, and continued six days, but was preceded by a preliminary observation of three days in which the subject consumed the same kinds and amounts of food, except that during the preliminary period he ate 550 grams of rice per day as compared with 600 grams during the actual experiment. The average air temperature during the period was 17° C. The subject, S. A., weighed at the beginning 49.9 kilograms and at the end 49.5 kilograms. The diet was of the same nature as that in experiment No. 41, and the daily menu was so arranged that the amount of protein per day was nearly the same as in that experiment, whereas the amount of energy furnished was much greater. The percentage of nitrogen in rice, miso, shoyu, and tea infusion was determined. The composition of the other foods was estimated.

During this study the subject gained nitrogen upon a diet supplying 56 grams of protein and having a fuel value of 2,375 calories of energy per day.

^a Tokyo Igakukai Zasshi (Jour. Tokyo Med. Soc.), 6 (1892), p. 139.

The data regarding the kinds and amounts of food used and the nutrients and energy supplied during experiments Nos. 35-42 are given in the following table:

TABLE 49.—Results of dietary experiments Nos. 37-42.

Kinds and amounts of food consumed.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Experiment No. 35.—Amounts per man, 10 days.</i>				
ANIMAL FOOD.				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Meats: Beef (14), 470 grams.....	9.4	2.4		
Fish: Salmon (28), 560 grams; porgy (4), 470 grams.....	21.6	7.5		
Eggs (1), 324 grams.....	4.1	3.9	0.2	
Total animal food.....	35.1	13.8	.2	
VEGETABLE FOOD.				
Cereal: Rice (45), 4,800 grams.....	38.0	5.1	361.4	
Sugar, 45 grams.....			4.5	
Legumes and their preparations: Miso (76), 415 grams; shoyu (82), 265 grams.....	7.8	2.5	5.8	
Vegetables: Onion (9), 220 grams; radish (11), 1,420 grams; taro (12), 885 grams.....	2.6	.1	16.6	
Total vegetable food.....	48.4	7.7	388.3	
Total food { Total nutrients.....	83.5	21.5	388.5	
{ Digestible nutrients.....	a 72.7	18.3	380.7	2,091
<i>Experiment No. 36.—Amounts per man, 7 days.</i>				
ANIMAL FOOD.				
Meats: Beef (14), 440 grams.....	12.6	3.3		
Fish: Dab (2), 130 grams; salmon, fresh (28), 120 grams; salmon, salted (29), 100 grams; <i>Salanz microdon</i> (6), 80 grams.....	13.7	4.0		
Eggs (1), 602 grams.....	10.8	10.4	.5	
Total animal food.....	37.1	17.7	.5	
VEGETABLE FOOD.				
Cereal: Rice (45), 3,020 grams.....	28.2	4.6	324.9	
Sugar, 35 grams.....			5.0	
Legumes and their preparations: Miso (76), 140 grams; shoyu (82), 320 grams.....	6.5	1.2	4.1	
Vegetables: Lotus rhizome (8), 255 grams; onion (9), 380 grams; taro (12), 700 grams; radish, pickled (13), 520 grams.....	3.8	.2	22.5	
Total vegetable food.....	38.5	6.0	356.5	
Beverage: Sake, 1,950 cubic centimeters.....	3.4		(62.1)	
Total food { Total nutrients.....	79.0	23.7	419.1	
{ Digestible nutrients.....	a 69.8	20.2	410.7	2,222
<i>Experiment No. 37.—Amounts per man per day.</i>				
ANIMAL FOOD.				
Fish: Salmon, salted (29), 100 grams.....	26.5	3.1		
VEGETABLE FOOD.				
Cereal: Rice (43), 500 grams.....	39.6	5.3	376.5	
Sugar, 5 grams.....			5.0	
Legumes and their preparations: Miso (76), 25 grams; shoyu (82), 15 grams.....	4.6	1.5	3.5	
Vegetables: Radish (11), 50 grams; taro (12), 150 grams.....	2.5	.1	19.4	
Total vegetable food.....	46.7	6.9	404.4	
Total food { Total nutrients.....	73.2	10.0	404.4	
{ Digestible nutrients.....	a 64.4	8.5	396.3	2,028

a See page 185.

TABLE 49.—Results of dietary experiments Nos. 37-42—Continued.

Kinds and amounts of food consumed.	Nutrients and energy per man per day.			
	Protein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Experiment No. 37a.—Amounts per man per day.</i>				
ANIMAL FOOD.				
Fish: Salmon, salted (29), 85 grams.....	Grams. 22.5	Grams. 2.7	Grams.	Calories.
VEGETABLE FOOD.				
Cereal: Rice (43), 550 grams.....	43.5	5.9	414.2	
Sugar, 5 grams.....			5.0	
Legumes and their preparations: Miso (76), 25 grams; shoyu (82), 15 grams.....	4.7 2.5	1.5 .1	3.4 19.4	
Vegetables: Radish (11), 50 grams; taro (12), 150 grams.....	50.7	7.5	442.0	
Total vegetable food.....				
Total food {Total nutrients.....	73.2	10.2	442.0	
{Digestible nutrients.....	a 62.8	8.7	433.2	2,178
<i>Experiment No. 38.—Amounts per man, 10 days.</i>				
Cereal: Rice (43) 5,300 grams.....	41.9	5.7	399.1	
Sugar, 50 grams.....			5.0	
Legumes and other vegetables: Beans, cooked (75), 800 grams; miso (76), 400 grams; shoyu (82), 195 grams; tofu (7), 256 grams; onion (9), 120 grams; radish (11), 150 grams; radish, pickled (13), 673 grams; taro (12), 680 grams.....	40.9	18.3	37.7	
Total food {Total nutrients.....	82.8	24.0	441.8	
{Digestible nutrients.....	a 68.5	19.7	433.0	2,303
<i>Experiment No. 39.—Amounts per man per day.</i>				
Cereal: Rice (43), 450 grams.....	35.6	4.8	338.9	
Sugar, 5 grams.....			5.0	
Legumes and their preparations: Miso (76), 50 grams; shoyu (82), 15 grams.....	8.0	3.0	6.3	
Vegetables: Potatoes (10), 100 grams; radish (11), 50 grams; taro (12), 150 grams.....	4.0	.2	38.6	
Total food {Total nutrients.....	47.6	8.0	388.8	
{Digestible nutrients.....	a 36.8	6.6	381.0	1,824
<i>Experiment No. 40.—Amounts per man per day.</i>				
Cereal: Rice (44), 550 grams.....	35.7	5.9	414.2	
Sugar, 15 grams.....			15.0	
Legumes and their preparations: Miso (77), 75 grams; shoyu (81), 50 grams.....	12.5	4.5	10.5	
Vegetables: Taro (12), 250 grams; radish, pickled (13), 50 grams.....	4.2	.2	32.3	
Total food {Total nutrients.....	52.4	10.6	472.0	
{Digestible nutrients.....	a 40.5	8.7	462.6	2,200
<i>Experiment No. 41.—Amounts per man per day.</i>				
Cereal: Rice (45), 550 grams.....	35.9	5.9	414.2	
Sugar, 10 grams.....			10.0	
Legumes and their preparations: Miso (79), 50 grams; shoyu (82), 40 grams.....	9.9	3.0	7.3	
Vegetables: Onion (9), 60 grams; taro (12), 200 grams; radish, pickled (13), 60 grams.....	4.5	.2	29.6	
Total food {Total nutrients.....	50.3	9.1	461.1	
{Digestible nutrients.....	a 34.4	7.5	451.9	2,119
<i>Experiment No. 42.—Amounts per man per day.</i>				
Cereal: Rice (44), 600 grams.....	38.9	6.4	451.8	
Sugar, 15 grams.....			15.0	
Legumes and their preparations: Miso (77), 75 grams; shoyu (81), 50 grams.....	12.6	4.5	10.5	
Vegetables: Taro (12), 250 grams; radish, pickled (13), 60 grams.....	4.3	.2	32.9	
Total food {Total nutrients.....	55.8	11.1	510.2	
{Digestible nutrients.....	a 43.5	9.1	500.0	2,376
Beverage: Tea decoction (127a), 250 cubic centimeters.....	.2			

a See page 185.

The investigators concluded that the failure to establish a nitrogen balance in experiments Nos. 39 and 41 was due to an insufficient amount of energy rather than to the small amount of protein in the diets of the different subjects. In experiments Nos. 40 and 42, in which the amounts of protein supplied by the diet differed but very little from those in the corresponding experiments Nos. 39 and 41, while the amounts of energy in the former experiments were larger, the subjects gained nitrogen. These results are fully in accord with those obtained by Kumagawa (experiments Nos. 27-30). The investigators believed that with people who have been accustomed to such vegetable diets all their lives the utilization of the food materials might be much better than is indicated by these results with subjects unaccustomed to such diets.

In experiments Nos. 37 and 37a the quantity of protein in the diet was exactly the same, but the amount of carbohydrates in the daily diet was larger in the latter. In order to furnish more carbohydrates, about 50 grams more rice was used in the second period than in the first period, and the amount of salmon was reduced by 15 grams to compensate for the protein added in the rice. There was a slight difference in the amount and nitrogen content of the feces for the two periods. There was 0.3 gram per day more nitrogen in the feces in the second period than in the first, which would indicate that the protein in rice was somewhat less digestible than that in salmon (see p. 185). A comparison of the results for the two periods indicates that the carbohydrates tended to act as a protector of protein. The average daily amount of nitrogen eliminated in the urine during the first period was 9.9 grams, whereas in the second period it was only 8.8 grams.

EXPERIMENTS WITH A LABORATORY SERVANT (Nos. 59-65).

These experiments were made by K. Taniguchi,^a at the Army Medical College, Tokyo, in 1890. The object was to test the efficiency of a diet in which rice was the principal ingredient. In each case the digestibility of the protein of the diet was determined. (See p. 184.) The subject was a servant in the laboratory of the college, a healthy man weighing about 44 kilograms.

In experiments Nos. 59-61 a definite amount of rice was used, 712 grams each day, which is about the average amount eaten per day by a man at moderately hard work in Japan. The kind and quantity of supplemental food was different in each experiment. In experiments Nos. 62-65 the subject was allowed free choice of food as regards both kinds and amounts, the only condition being that the supplemental

^a Gun-i Gakko Gyofu (Arb. K. Japan. Militär-Ärztl. Lehranst.); [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 85.

food should consist entirely of vegetables. The kinds of vegetables used were not stated in the original report. In every case, except experiment No. 62, the quantity of rice actually eaten by the subject averaged 712 grams per day, the same as during the first three experiments. The food materials in each study were sampled and analyzed, the rice being sampled by itself and the supplemental foods being combined into a composite sample. The results of the analyses were not reported.

The data regarding the kinds and amounts of food and nutrients are summarized in the following table:

TABLE 50.—*Results of dietary experiments Nos. 59-65.*

Experiment No.	Date.	Duration.	Kind and amounts of food per man per day.	Nutrients and energy per man per day.			
				Protein.	Fat.	Carbohydrates.	Fuel value.
				Grams.	Grams.	Grams.	Cals.
59	1890. Apr. 23-24.....	2	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Beef extract, 20 grams.....	9.2	.....	10.5	.....
			Total food.....	69.4	4.7	586.9	.....
			Digestible nutrients.....	a 63.7	4.0	575.1	2,733
60	Apr. 25-28.....	4	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Radish, pickled, 244 grams.....	4.4	.5	25.9	.....
			Total food.....	64.6	5.2	602.3	.....
			Digestible nutrients.....	a 50.2	4.3	590.3	2,740
61	Apr. 29-May 8.....	10	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Miso, 171 grams.....	20.7	8.5	61.9	.....
			Total food.....	80.9	13.2	638.3	.....
			Digestible nutrients.....	a 66.5	10.8	625.5	3,000
62	May 18-27.....	10	Rice, 655 grams.....	55.4	4.4	530.5	.....
			Accessory food, 164 grams.....	4.7	.4	24.7	.....
			Total food.....	60.1	4.8	555.2	.....
			Digestible nutrients.....	a 47.6	3.9	544.1	2,530
63	May 28-June 6.....	10	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Accessory food, 172 grams.....	5.6	.4	23.7	.....
			Total food.....	65.8	5.1	600.1	.....
			Digestible nutrients.....	a 52.6	4.2	588.1	2,740
64	June 7-16.....	10	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Accessory food, 145 grams.....	4.5	.2	21.5	.....
			Total food.....	64.7	4.9	597.9	.....
			Digestible nutrients.....	a 52.8	4.0	585.9	2,730
65	June 17-21.....	5	Rice, 712 grams.....	60.2	4.7	576.4	.....
			Accessory food, 128 grams.....	4.8	.2	28.1	.....
			Total food.....	65.0	4.9	604.5	.....
			Digestible nutrients.....	a 50.0	4.0	592.4	2,745

a See page 186.

In each study except Nos. 60 and 62 the subject gained slightly in nitrogen. In study No. 60 he lost on the average 0.8 gram of nitrogen daily, though he attained nitrogen equilibrium on the last day of the study. In study No. 62, with a diet supplying 60 grams of protein and having a fuel value of 2,530 calories of energy, the subject could not attain nitrogen equilibrium even at the end of ten days. In the

three remaining studies, with a diet supplying 65 to 66 grams of protein per day and having a fuel value of 2,730 to 2,745 calories of energy the subject could maintain nitrogen equilibrium. The investigator concluded that the subject obtained sufficient protein and energy to maintain bodily equilibrium under the conditions of the experiment from a simple diet consisting of rice and vegetables selected according to free choice.

EXPERIMENTS WITH RICE AND RICE-BARLEY DIETS (Nos. 67-73).

These studies were made in the army by G. Oi,^a and cited by R. Mori, but he did not give the exact date of the investigation.^b The object of the investigation was to determine the relative merits of diets in which rice and rice-barley mixture were the chief food materials. Especial attention was given to the digestibility of the protein in the diets. (See p. 184.)

Seven experiments, each continuing three days, were made as follows: One with rice supplemented by fish, one with rice and tofu, and one with rice and vegetables, and three corresponding experiments with rice-barley and the same supplemental foods; there was also one experiment with rice-barley and meats for which there was no corresponding experiment with rice.

The subjects in each experiment were 3 military nurses, weighing respectively 55.8, 62.5, and 63.9 kilograms. In order that the experiments might be strictly comparable, the diet in each was very carefully regulated. The quantity of the principal food, rice or rice-barley, was almost exactly the same per subject for all the experiments, and the quantity of supplemental food was likewise uniform throughout; and the kind of supplemental food in an experiment with rice was the same as in the corresponding experiment with rice-barley.

Samples of the cooked rice, the rice-barley mixture (comprising 7 parts of rice to 3 parts of barley), and of each supplemental food were obtained and analyzed, these data being included in Table 6.

The kinds and amounts of food per man per day, and the nutrients and energy supplied, are given in Table 51. In Mori's citation the amounts of fat and carbohydrates in the food eaten were not given, as he confined his discussion to the digestibility of the protein of the different diets. The results here given were computed by the compiler, from the data reported. The amounts of protein thus computed do not agree exactly with those in the report, but the discrepancies were so slight that the reporter's figures for protein have been retained here.

^a Gun-i Gakko Gyofu (Arb. K. Japan. Militär-Arztl. Lehranst.); [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 108.

^b In his citation Mori stated that the original report by Oi was published in 1886, but a copy of this report could not be obtained by the compiler.

TABLE 51.—Results of dietary experiments Nos. 67-73.

Dietary No.	Kinds and amounts of food per man per day.	Nutrients and energy per man per day.			
		Protein.	Fat.	Carbo-hydrates.	Fuel value.
		Grams.	Grams.	Grams.	Calories.
67	Rice, cooked (53), 1,680 grams.....	42	5	527	.....
	Fish, cooked (133), 888 grams.....	86	40	76	.....
	Total food eaten { Total nutrients.....	a 128	45	603	.....
	{ Digestible nutrients.....	125.3	38.3	590.9	3,393
68	Rice, cooked (53), 1,680 grams.....	42	5	527	.....
	Tofu, cooked (132), 888 grams.....	33	23	18	.....
	Total food eaten { Total nutrients.....	75	28	545	.....
	{ Digestible nutrients.....	a 74.5	23.8	534.1	2,795
69	Rice, cooked (53), 1,676 grams.....	42	5	525	.....
	Vegetables, cooked (134), 888 grams.....	8	1	125	.....
	Total food eaten { Total nutrients.....	50	6	650	.....
	{ Digestible nutrients.....	a 49.6	4.9	637	2,940
70	Rice-barley, cooked (55), 1,680 grams.....	54	12	497	.....
	Meats, cooked (135), 888 grams.....	81	39	116	.....
	Total food eaten { Total nutrients.....	135	51	613	.....
	{ Digestible nutrients.....	a 127.7	43.4	594.6	3,467
71	Rice-barley, cooked (55), 1,680 grams.....	54	12	497	.....
	Fish, cooked (133), 888 grams.....	86	40	76	.....
	Total food eaten { Total nutrients.....	140	52	573	.....
	{ Digestible nutrients.....	a 131.3	44.2	555.8	3,328
72	Rice-barley, cooked (55), 1,680 grams.....	54	12	497	.....
	Tofu, cooked (132), 888 grams.....	33	23	18	.....
	Total food eaten { Total nutrients.....	87	35	515	.....
	{ Digestible nutrients.....	a 78.3	29.8	499.6	2,720
73	Rice-barley, cooked (55), 1,680 grams.....	54	12	500	.....
	Vegetables, cooked (134), 888 grams.....	8	1	125	.....
	Total food eaten { Total nutrients.....	62	13	625	.....
	{ Digestible nutrients.....	a 61.0	10.7	606.3	2,914

a See page 186.

In each parallel study with rice and rice-barley diets the digestibility of protein was much higher in the former than in the latter (see p. 186).

SUMMARY AND DISCUSSION.

As previously explained (p. 52), the total number of investigations of food consumption to which reference was found was 376, though they appear in this compilation as 121, for the reason given. They were made in different parts of the country, and with people of different classes. The total number of subjects included in the investigations, so far as can be ascertained from the reports, was not less than 2,450, as will be seen from Table 52.

TABLE 52.—*Distribution of Japanese dietary studies.*

Class.	Number of studies.	Number of persons.
Professional men.....	21	21
Students and cadets.....	19 (11)	279
Men at hard work.....	3 (1)	3
Miscellaneous.....	7 (3)	1,103
Army.....	301 (263)	372
Navy ^a	9 (4)	675
Total.....	360	2,453

^a This does not include studies of ration allowance, Nos. 103-121.

The figures in parentheses indicate the number of studies in which the number of subjects was not stated. In estimating the total number of persons it was assumed that in each of these studies there was one subject, but in some of the studies, especially those in the army, the number was much larger.

The food materials used in these investigations were among those most commonly used in Japan, and in character and composition were fairly representative of the diet of people of the classes studied. As regards amounts of food consumed, also, the results of the investigation furnished considerable information concerning the dietary customs of the different classes represented. On the whole, then, the investigations give a fair idea of the food consumption of a limited portion of the population of Japan; they do not, however, afford a satisfactory idea regarding the dietary habits of the Japanese people in general, because they were made for the most part with representatives of the professional and commercial classes and the army and navy, little attention having been given to the diet of the laboring classes in either city or country. Even the agricultural laborer in the only dietary study among rural peasantry was a military colonist. It is unfortunate that the food and dietary habits of the Japanese peasants have thus far been studied scarcely at all, because this class of people forms by far the larger part of the population. Nevertheless, the results of the studies actually made are interesting indeed, and so much information may be derived from them that they are here summarized according to the different classes of subjects, and some deductions drawn from them.

PROFESSIONAL AND BUSINESS MEN'S DIETARIES.

The dietary studies with professional and business men are summarized in Table 53. The studies with regular diet are given in the upper part of the table, while those which were more or less of a special nature are given separately. For sake of comparison the table includes also results of studies with professional men in other countries.

TABLE 53.—Summary of results of dietary studies with professional and business men.

Diet- ary No.	Subjects.				Food.	Nutrients and energy per man per day. ^a							
	Occupation.	Num- ber of per- sons.	Age.	Weight. Kilos.		Dura- tion.	Total.			Digestible. ^b		Carbo- hydrates.	Fuel value
							Protein.	Fat.	Carbo- hydrates.	Protein.	Fat.		
			Years.		Days.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.	
<i>Regular studies.</i>													
16	Physiologist.....	1	.....	45	17	86	26	226	75	22	222	1,470	
17	Chemist.....	1	.....	45	6	84	22	352	73	19	345	1,945	
19	do.....	1	23	52	6	123	21	416	c 111	18	c 413	2,380	
20	do.....	1	23	52	6	109	19	466	c 95	17	c 464	2,530	
22	School business agent.....	1	49	57.7	10	75	13	504	65	11	494	2,465	
23	Physician.....	1	24	.....	2	71	9	478	62	8	469	2,315	
24	Merchant.....	1	28	47.6	10	94	23	374	82	20	366	2,080	
27	Physician.....	1	27	48.9	13	90	16	489	c 76	13	479	2,470	
35	Laboratory assistant.....	1	20	43.0	10	84	22	388	c 73	18	381	2,090	
36	Physician.....	1	30	49.5	7	79	24	419	c 70	20	411	2,220	
37	Laboratory assistant.....	1	20	42.9	7	73	10	404	c 64	9	396	2,030	
37a	do.....	1	20	43.0	6	73	10	442	c 63	9	433	2,180	
38	do.....	1	20	43.0	10	83	24	442	c 69	20	433	2,305	
Average 13 studies.....													
Professional men in United States (average 14 studies). ^d													
German physicians (average 2 studies). ^d													
.....													
<i>Special studies.</i>													
21	Chemist.....	1	23	52	6	71	12	414	c 54	10	c 399	2,000	
28	Physician.....	1	27	48.3	5	58	2	442	c 47	2	433	2,045	
29	do.....	1	27	48.5	5	44	2	442	c 34	2	433	1,980	
30	do.....	1	27	48.7	9	55	3	571	c 42	2	559	2,555	
39	Laboratory assistant.....	1	20	43.6	8	48	8	389	c 37	7	381	1,825	
40	do.....	1	20	43.3	7	52	11	472	c 41	9	463	2,200	
41	Physician.....	1	30	49.6	6	56	9	461	c 34	8	452	2,120	
42	do.....	1	30	49.7	6	56	11	510	c 44	9	500	2,375	
Average 8 studies.....													
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^a The quantities are those actually eaten.^b Calculated by use of the factors given on page 206 unless otherwise stated.^c Actually determined in corresponding digestion experiments.^d U. S. Dept. of Agr., Farmers' Bul. 142, p. 35.

The actual amounts of protein and energy in the diet of the Japanese professional men are noticeably smaller than in that of professional men in America. It is to be remembered, however, that the former are much smaller and lighter in weight.^a The Japanese professional men whose dietaries were studied weighed not far from 49 kilograms, according to the average of ten records of body weight. If it is assumed that the average American professional man weighs 65 kilograms and the amounts of protein and energy in the dietaries of the Japanese professional men are recalculated on the basis of this weight, the average results would indicate that the diet was equivalent to one of 138 grams of protein and 2,900 calories of energy per man per day for the heavier individual. Apparently, then, the dietaries of the Japanese professional men would compare favorably with those of American professional men when the lighter weight of the former is taken into account.

The amount of animal food used in the dietaries of professional men may fairly represent that in the dietaries of well-to-do classes in general. It varied from 54 to 299 grams per day, the average being 163 grams.

From Table 60 (p. 131) it will be seen that animal food furnished only 38 per cent of the total protein in the diet. The principal animal food was fish, which furnished 61 per cent of the total animal protein. By far the most important source of protein in the diet was cereals, principally rice. In study No. 24 a considerable quantity of bread was used, but in all other studies rice was practically the only cereal.

STUDENTS' DIETARIES.

The results of the dietary studies made with students are summarized in the following table, which also includes for the sake of comparison average results of dietary studies among American college clubs:

^aAccording to such statistics as the compiler could obtain, the average weight of Japanese men of all classes is approximately 53 to 58 kilograms; that of Europeans is about 63 to 65, and that of Americans 67 to 69 kilograms.

TABLE 54.—Summary of results of dietary studies with students.

Dietary No.	Subjects.			Diet.	Duration.	Nutrients and energy per man per day. ^a						
	Occupation.	Num-ber of per-sons.	Age.			Weight.	Total.		Digestible. ^b		Fuel value.	
							Protein.	Carbo-hydrates.	Protein.	Fat.		Carbo-hydrates.
						Grams.	Grams.	Grams.	Grams.	Grams.	Calories.	
1	Medical student.....	1	Years. 20	Kilos. 49	Rice, meat, fish, etc.....	5	86	334	11	73	1,810	
2	do.....	1	24	54	do.....	5	110	346	98	15	2,810	
12	Higher normal school stu- dents.	130	17-25	53	do.....	10	118	638	103	27	3,330	
13	Private school pupils ^c	{	21	11-14	} Rice, fish, and vegetables.....	7	81	472	71	11	2,355	
14	do.....		48	15-21		48	7	77	454	69	9	2,240
1-33	University students (average 3 studies).		63	14-24		44	3	54	463	46	16	2,265
	Average 8 studies: By persons ^c	267					98	548	85	18	2,800	
	By studies.....						79	479	69	15	2,415	
8	Military cadets.....		(/)		Mixed vegetable and animal food.		83	631	72	12	3,020	
53	Military cadets (average 2 studies).				do.....	7-12	125	591	109	20	3,105	
54	Military cadets.....				do.....		113	539	98	22	2,890	
55	Military cadets (average 2 studies).				do.....	7-14	116	550	101	19	2,885	
56	Military cadets.....				do.....		108	630	94	21	3,205	
57	do.....				do.....	7	112	704	87	13	3,440	
58	Military cadets (average 3 studies).				do.....		114	695	99	23	3,510	
	Average 11 studies.....						113	625	98	20	3,185	
	College clubs in United States (average 15 studies). ^d						107	459	98	141	3,580	

^a In studies Nos. 1, 2, 31-33, the quantities are those actually eaten; in the other Japanese studies some waste may be included.^b In Japanese studies calculated by factors given on page 208.^c The amounts of nutrients and energy are per person per day. See description of the studies, page 62.^d Number of persons is 59.^e The average of persons is computed by counting each medical student as 1, normal school students as 130, etc.^f Ages not stated; majority probably 18-21 years.^g U. S. Dept. of Agr., Farmers' Bul. 142, p. 35.

In general the dietaries of the military cadets contained somewhat larger amounts of protein and energy than those of other students, though those of the higher normal school students and of one of the medical students agree fairly well with the average for the cadets in respect to the quantities of both protein and energy. The dietaries of the Japanese students as a whole compare favorably with those of the average American college clubs.

In all these dietaries some animal food was used. It was not possible in every case to estimate the amount of animal food and of the nutrients supplied by it, but from such data as were available it appears that the animal food used varied from 57 to 213 grams per day, the average amount being 127 grams. According to the figures in Table 60 (p. 131), animal food furnished only 28.7 per cent of the total protein while cereals furnished 54.8 per cent. In some of the dietaries the legumes and their preparations furnished nearly as much protein as was obtained from fish. Rice was almost the only cereal used in all these dietaries.

DIETARY STUDIES WITH MEN AT HARD WORK.

The following table summarizes the results of Japanese dietary studies with men at hard work. Average results of some American and European studies of men at hard work are also included for comparison.

Although the number of studies of this class is too limited to warrant any general conclusion, the results indicate that among hard-working people in Japan large amounts of protein and energy are used. This is especially noticeable in the study with the jinrikisha man. This latter study compares very favorably with those of American rowing clubs and bicycle racers in respect to the amounts of both protein and energy.

The amount of carbohydrates in the Japanese dietaries in the above table is nearly twice that in the American studies, which compensates for the small amount of fat in the former.

The amount of rice eaten by the men in these studies is very large, being nearly twice the average amount noticed in the studies with professional men and students.

DIETARY STUDIES IN THE ARMY.

The results of the dietary studies conducted with various groups and individuals in the Japanese army are here summarized. The regular studies given in the upper part of the table are those in which the food consumption of large groups was determined in the regular way. In each case what is numbered as a single study in this compilation is actually an average of several studies. The special studies in the lower part of the table are the determinations of the food consumption made in connection with special investigations of different kinds of rations.

TABLE 56.—*Summary of dietary studies in the Japanese army.*

Diet- ary No.	Subjects.			Food.	Dura- tion.	Nutrients and energy per man per day. ^a						Fuel value.
	Occupation.	Num- ber of per- sons.	Age.			Weight.	Total.		Digestible. ^b		Carbo- hydrates.	
							Protein.	Fat.	Carbo- hydrates.	Protein.			Fat.
				Kilos.	Days.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
43-44	Regular studies.											
45-46	Infantry (average 164 studies)			60		123	22	665	107	19	652	3,385
47-48	Cavalry (average 19 studies)			59		124	19	712	108	16	698	3,560
49-50	Artillery (average 26 studies)			64		121	21	636	105	18	623	3,250
51-52	Engineers (average 32 studies)			59		135	23	636	117	20	623	3,315
	Provision corps (average 20 studies)			58		112	23	630	97	20	617	3,205
	Average, 261 studies					124	22	659	108	19	646	3,360
59	Special studies.											
60	Laboratory servant.	1		44		69	5	587	64	4	575	2,735
61	do.	1		44		65	5	602	50	4	590	2,740
62	do.	1		44		81	13	638	67	11	626	3,000
63	do.	1		44		60	5	555	48	4	544	2,530
64	do.	1		44		66	5	600	53	4	588	2,745
65	do.	1		44		65	5	598	53	4	586	2,730
66	do.	1		44		65	5	605	50	4	592	2,745
67	Military nurses	3		60.7		128	45	603	125	38	591	3,395
68	do.	3		60.7		75	28	545	74	24	534	2,795
69	do.	3		60.7		50	6	650	49	5	637	2,940
70	do.	3		60.7		135	51	613	128	43	595	3,465
71	do.	3		60.7		140	52	573	131	44	556	3,330
72	do.	3		60.7		87	35	515	78	30	500	2,720
73	do.	3		60.7		62	13	625	61	11	606	2,915
74-79	Soldiers (average, 6 individ- ual tests).	6	24	58.2	8	85	15	534	71	12	526	2,635
80-85	do.	6	23	58.8	8	78	13	476	55	11	460	2,275
87-92	do.	6	24	58.9	8	79	21	442	64	18	428	2,250
93	Military nurse.	40	46	52.2	8	68	13	293	42	11	258	1,370
94	do.	10			7	84	20	611	73	17	599	2,990
95	do.	10			12	85	20	626	82	17	607	3,065
96	do.	10			12	113	55	460	110	47	507	2,790
102	Army surgeon.	1		54	4	92	14	521	79	12	502	2,565
	Average, 37 studies:											
	By persons.	108				88	24	568	78	20	554	2,890
	By studies.					82	19	528	69	16	513	2,610

^a In the special studies the quantities are those actually eaten; in the regular studies some waste may be included. (See p. 82.)

^b Calculated by use of the factors given on page 206.

^c Actually determined in corresponding digestion experiments.

It will be seen from the above results that the Japanese army ration contains a liberal supply of protein and energy. The amounts of nutrients in studies Nos. 43-52 are larger than in the other individual dietaries. This may be explained in part by the fact that in all of the individual studies the foods were analyzed and the wastes, if any, were recorded and deducted, while in the other studies the foods were not analyzed, composition being assumed from that of previous analyses of similar materials, and some waste may also be included in the results.

PRESENT JAPANESE ARMY RATION.

According to unpublished data received while this bulletin was being edited, the daily ration of the Japanese soldier at the present time (1905) consists of 30 ounces rice, 5.33 ounces canned meat, 1.25 ounces salt plums or 0.4 ounce salt, and 0.63 ounce shoyu. The emergency ration consists of 15 ounces dried rice or 24 ounces hard bread, with 5.33 ounces canned meat, and 0.4 ounce salt. On the basis of average figures the nutritive value of these rations has been calculated as follows:

TABLE 57.—*Nutrients and energy furnished by the Japanese army, regular and emergency rations.*

Kind of food.	Pro- tein.	Fat.	Carbo- hy- drates.	Amount.	Pro- tein.	Fat.	Carbo- hydrates.	Fuel value.
<i>Regular ration.</i>								
Canned meat ^a	<i>Per ct.</i> 24.7	<i>Per ct.</i> 14.2	<i>Per ct.</i>	<i>Grams.</i> 151	<i>Grams.</i> 37	<i>Grams.</i> 21	<i>Grams.</i>	<i>Calories.</i>
Rice.....	8.0	.3	79.0	862	69	3	681	.....
Salt plums ^b	.4	.....	13.6	38	.....	.....	5	.....
Soy.....	9.3	.....	4.9	19	2	.....	1	.....
Total.....	.....	.....	.....	.....	108	24	687	c 3,430
<i>Emergency ration.</i>								
Canned meat ^a	24.7	14.2	.....	151	37	21	.....	.....
Rice.....	8.0	.3	79.0	423	34	1	334	.....
or	.....	.....	.....	.....	.....	.....	.....	.....
Hard bread ^d	11.1	5.0	74.2	680	75	34	505	.....
Salt.....	.....	.....	.....	11	.....	.....	.....	.....
Total when rice is served	.....	.....	.....	.....	71	22	334	1,825
Total when hard bread is served.....	.....	.....	.....	.....	112	55	505	2,945

^a Percentage composition taken as average of 14 analyses of canned roast beef.

^b Percentage composition assumed from data in Japanese dietary studies. In place of salt plums salt may be served.

^c Calculated by use of factors for fuel values of nutrients in Japanese diet.

^d Percentage composition assumed as that of pilot bread.

A common American dietary standard for a man at light to moderate muscular work calls for 103 grams digestible protein and 3,050 calories of energy. Similar values for a man at moderately active muscular work are 115 grams protein and 3,400 calories of energy, and at severe muscular work 138 grams protein and 4,150 calories of energy. Commonly accepted European dietary standards are somewhat like these. Taking into account both the work done and the weight of the soldiers, which is on an average undoubtedly less than that of the United States or European troops, it will be seen that the army ration is adequate as regards both protein and energy, and that it has evidently been fixed upon with a view to meeting the requirements of commonly accepted dietary standards.

DIETARY STUDIES IN THE NAVY.

Table 58 summarizes the results of dietary studies made on board of individual battle ships in the navy, and includes also the navy ration on a peace footing as revised in 1900.

TABLE 58.—*Summary of results of dietary studies in the Japanese navy.*

Dietary No.	Subjects.		Food.	Duration	Nutrients and energy per man per day.								Fuel value.
	Occupation	Number of persons.			Total.			Digestible. ^a			Carbo-hydrates.		
					Protein.	Fat.	Carbo-hydrates.	Protein.	Fat.	Carbo-hydrates.			
				Days.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.	
4	Marines.....	284-309	Navy rations	271	91	14	586	79	12	574		2,875	
5	Cadets.....	27	do.	271	106	32	587	92	27	575		3,070	
6	Under officers	27	do.	271	117	42	507	102	35	497		2,865	
7	Officers.....	15	do.	222	147	59	600	128	50	588		3,510	
18	Marines.....	31	do.	61	124	59	523	108	50	512		3,065	
34	do.....	31	do.	146	146	54	553	127	46	542		3,265	
95	do.....	322	do.	204	146	54	553	127	46	542		3,265	
120			Good (1900) allowance at sea, peace.		146	29	586	127	24	574		3,200	
121			Revised (1900) allowance on land or in harbor, peace.		155	33	594	135	28	582		3,300	
			Average of Nos. 120 and 121.....		151	31	590	131	26	578		3,250	

^a Calculated by use of the factors given on page 206.

It will be seen from the figures that the amounts of protein and energy in the Japanese navy ration are proportionately large; they compare favorably with those in the United States navy ration, which furnishes about 145 grams of protein and 4,280 calories of energy. Studies Nos. 4-7 were conducted on board of a battle ship in which were a large number of beriberi patients during the year when the improved ration had not yet been adopted. These dietaries in general supplied a smaller amount of protein than the other dietaries in the navy which have been studied since the improved ration was adopted. The navy ration contains the largest amount of protein found in any of the studies here compiled. It also contained the largest amount of animal food of any of the Japanese dietaries, the average amount per man per day being 317 grams. About 45 per cent of the total protein of the diet is derived from animal sources, 14 per cent from fish, and 31 per cent from meat and other animal foods. (See p. 131.) A considerable amount of bread is used and some rice, though rice does not form such an important part of the navy ration as in other Japanese dietaries.

RESULTS OF MISCELLANEOUS DIETARY STUDIES.

The results of several miscellaneous Japanese dietary studies are summarized in the following table. For the sake of comparison, the results of dietary studies of the inhabitants of the Java village at the Columbian Exposition at Chicago and of studies with Malay servants and Indo-Chinese laborers are also given.

TABLE 59.—*Summary of results of miscellaneous dietary studies.*

Diet- ary No.	Subjects.			Food.	Dura- tion.	Nutrients and energy per man per day.							Fuel value.
	Occupation.	Num- ber of per- sons.	Age.			Weight.	Total.			Digestible. ^a			
							Protein.	Fat.	Carbo- hydrates.	Protein.	Fat.	Carbo- hydrates.	
			Y'ears.	K'ilos.		Days.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
3	Man nurse.....	1	36½	48.5	Meat, fish, rice, and vegeta- bles.	5	74	6	65	5	479	470	2,305
9	Prisoners without work.....			47.6	Rice, barley, and vegetables.	7	48	7	36	6	372	380	1,725
10	Prisoners at light work.....			48.0	do.....	7	57	8	43	6	458	444	2,110
11	Prisoners at heavy work.....				do.....	7	75	9	57	8	630	611	2,885
b15	Clerks in retail store.....	{	21	32.9	Fish, rice, and vegetables....	7	57	6	49	5	395	387	1,890
99	Native Formosan.....	3	11-16	51.8	Rice and vegetables with very little fish.	2	48	9	37	7	417	408	1,950
100	Military colonist.....	1	20	59	Rice, millet, and vegetables..	7	59	8	46	6	594	583	2,705
101	Prisoners.....	1,011			Rice, barley, and vegetables with little animal food.	7	56	11	43	9	399	387	1,895
	Average, 8 studies.....						59	8	47	7	468	456	2,190
97	Military hospital patients....				Rice, barley, meat, fish, and vegetables.	7	69	17	52	14	459	426	2,170
98	do.....				Rice, gruel, eggs, etc.....	7	47	27	41	23	211	207	1,265
	Java village, World's Fair, Chicago. ^c	5			Rice, meat, and vegetables..	10	66	19			254		1,490
	Malay young men ^d	8		50	Rice, fruit, eggs, etc.....		75	40			400		2,300
	Indo-Chinese laborers (Ana- mites, Yangtze River, winter). ^e				Rice, meat, bread, etc.....		127						3,600

^a Calculated by use of the factors given on page 206.^b The amounts of nutrients and energy are per person per day. See the explanation in the description of the experiment, page 63.^c U. S. Dept. of Agr., Office of Experiment Stations Bul. 21, p. 180.^d Arch. Path. Anat. u. Physiol. [Virchow], 131 (1893), p. 170.^e Compt. Rend. Soc. Biol. [Paris], 57 (1904), p. 210.

The amounts of protein and energy in these studies are very small, averaging 59 grams of protein and 2,190 calories of energy per man per day. The average digestibility of protein in the Japanese vegetable diets was about 78 per cent, while that of rice-barley diet containing animal food was about 76 per cent. The amount of protein actually available to the body in the dietaries summarized above must have been only about 45 to 47 grams per day. The dietaries of the inhabitants of the Java village and of the Malay servants contained nearly the same amounts of protein and energy as found in the dietaries of the Japanese of the same class. The Indo-Chinese laborers by comparison had a very generous diet. They were compelled to perform hard work during cold weather, and as their ordinary diet, consisting largely of rice, was found to be inadequate, the amount of carbohydrates was diminished and an extra amount of meat and fat added. Thus modified the diet was sufficient for their needs.

The subjects of some of the Japanese studies had very little muscular work to do. This is especially true of the prisoners included in studies Nos. 9 and 101. The results obtained in the study with native Formosans are noticeable. The three men included in this study were strong and healthy and heavier than the average Japanese. They were engaged in moderately active muscular work, yet their diet supplied only 45 grams of protein and 1,935 calories of energy per man per day. There is little doubt that some persons can live and work on a diet containing very small amounts of protein and energy, but in other cases it seems equally certain that the requirements are much larger. The results obtained with these men are in accord with what has been found in a number of other studies. It should be remarked, however, that the study in this case continued only two days.

Except in studies Nos. 3 and 15 the diet consisted almost entirely of vegetable food. In study No. 3 nearly 175 grams of animal food was used daily. This was considered, however, rather exceptional for persons of this class. In study No. 15, fish, which was the only animal food, furnished 14 per cent of the total amount of protein; whereas legumes and their preparations furnished 23 per cent. Cereals were the chief source of protein as well as of other nutrients in all these dietaries. In studies Nos. 3, 15, and 99, rice was the only cereal used. In the other studies rice and barley were consumed.

DEDUCTIONS.

ADEQUACY OF THE DIET.

As has been stated, persons in the army and navy, and those in comfortable circumstances in other classes, including professional and business men and students, are in general well nourished. The amounts of protein and energy in the diet of these classes compare

well with those in the diet of people under similar circumstances in Europe and America, especially when allowance is made for the smaller average weight of the Japanese.

Probably the most interesting of the dietary studies are those with poorer classes, which comprise by far the larger part of the population. The dietaries of the miscellaneous class, including employees, prisoners, etc., consisted largely of vegetable foods and supplied on an average 59 grams of protein and 2,190 calories of energy per man per day.

The study with the military colonist is the only one made with people in rural districts found on record, and is of considerable interest. The subject was considered fairly representative of his class. Although he was to a certain extent under military control, his diet was by no means influenced by that, because he was living with his family and had perfectly free choice in regard to food. His diet consisted of vegetable foods, and supplied 59 grams of protein and 2,700 calories of energy per man per day.

In the average of 24 studies of dietaries consisting of vegetable foods the amount of protein was found to be but 62 grams per day and that of energy 2,445 calories per day. It is probably fair to infer that the amount of protein in the dietaries of the classes living largely on vegetable foods may not be very far from 60 grams per day.

The small amount of protein in such dietaries has attracted the attention of many investigators in Japan, and has been the subject of much discussion and experiment. Investigations of this character have been summarized as "dietary experiments" in a preceding division of this section (p. 101), and in several instances the conclusions of investigators regarding the advisability of increasing the quantity of protein in the diet have been given.

Another noticeable fact is that the amount of fat in Japanese dietaries is very small. In the average of all mixed diets included in the present compilation the quantity of fat is only about 20 grams per day, and in the average of the vegetable diets only about 10 grams per day, or from about one-sixth to one-thirteenth of the amount found in the ordinary American diets. It will be noticed, however, that though the quantity of fat is small, the quantity of carbohydrates is generally relatively large.

It is sometimes remarked that the peasants in the rural districts of Japan, living largely on vegetable food, are really healthier and stronger than people of the better classes, who live on a mixed diet, and the better physical condition of the former is commonly believed to be due to their diet. The comparison, however, is hardly a fair one, because the general conditions of living other than diet are also much different among these classes. Baelz^a considers the poorer

^a Mitt. Deut. Gesell. Natur- u. Völkerk. Ostasiens, Tokyo, 4 (1885), No. 32, p. 55.

physique of the higher classes to be due to certain undesirable conditions of living resulting largely from the peace-pursuing policy of the Tokugawa Shogunate. The vital question, however, is not whether persons can keep well and strong upon a vegetable diet, for such is abundantly proven by practice and by experiment, but whether they can not be equally as well or perhaps much better and more advantageously nourished on a mixed diet.

There is indeed much experimental evidence that a man can live, maintain nitrogen equilibrium, and do a considerable amount of work with a small amount of protein in the diet. That people can live and thrive well upon a vegetable diet alone is also beyond question. The idea has been advanced, however, that although it is possible to sustain life and perform a considerable amount of work on a diet containing a very small amount of protein and commonly large amounts of carbohydrates and fat, people are actually better nourished when the nutrients of their diet are in about the amounts suggested by the commonly accepted dietary standards. It is also a very generally observed fact that people who are better nourished are much more capable of productive work. The productive power of the individual as well as of the nation depends doubtless upon many factors other than food, such as race, climate, habit, etc., but there is no gainsaying the fact that diet has also a profound and direct influence upon it.

The results of the Japanese dietary studies thus far made are interesting and valuable, but the studies have been confined chiefly to professional men in cities and to the military class in the army and navy. Before any general conclusions can be drawn it is necessary to have further studies and experiments on the dietary habits of Japanese people under various circumstances, and especially of the agricultural and laboring classes. Broader observations regarding bodily and mental efficiency and the general health, strength, and welfare are also essential.

PROPORTIONS OF TOTAL NUTRIENTS IN JAPANESE MIXED DIET SUPPLIED BY DIFFERENT GROUPS OF FOOD MATERIALS.

The amount of animal food used in the Japanese dietaries varies greatly, and in general is much less than that in the average American dietary. In many dietaries no animal food at all is found. It is interesting, therefore, to consider the sources of the different nutrients in the diet.

Of the 121 Japanese dietary studies included in the present compilation, 24 were with mixed vegetable diet and in the remainder the diet consisted of both animal and vegetable food. Unfortunately for this discussion, however, in the original reports of many of them the data were not given in such detail as to afford the means for estimating what proportions of the total quantity of each nutrient in the diet

was supplied by different groups of food materials. In only 25 of the studies, all of which were with mixed diet, were such estimates possible. These included 8 with professional men, 6 with students, 2 with men at hard work, and 9 studies in the navy. The data from these are here considered.

The food materials used in the various studies were divided into the following groups:

Total animal food; meats, eggs, etc.; fish; dairy products; total vegetable food; cereals; legumes and their preparations; vegetables. From the statistics of each study showing the total quantities of the nutrients—protein, fat, and carbohydrates—in each food material used the quantities of the nutrients in each group were found. Dividing the quantity of each nutrient in a group by the total quantity of the nutrient in the diet gave the proportion of the total nutrient that was supplied by that group. Such computations were made for each study of a certain class, and the average for all the studies of the class was then found. The details of these calculations, which are very numerous, are not included here. The discussion, however, is based upon the averages for each class, and for all 25 studies, as given in the following table, which also includes, for the sake of comparison, a similar average for 185 American studies.

TABLE 60.—*Proportions of total protein, fat, and carbohydrates supplied by different groups of food materials.*

Group.	Proportion of total quantity in the diet supplied by—								
	Total animal food.	Fish.	Meats, eggs, etc.	Dairy products.	Total vegetable food.	Cereals.	Sugars and starches.	Legumes and their preparations.	Vegetables.
Protein.	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Dietaries of professional men (average 8 studies).....	38.2	24.3	13.9	.....	61.8	46.0	.....	9.3	6.5
Dietaries of students (average 6 studies).....	29.1	(?)	(?)	.....	70.9	54.8	.....	9.4	6.7
Dietaries of men at hard work (average 2 studies).....	30.8	18.3	12.5	.....	69.2	58.4	.....	6.0	4.8
Dietaries in the navy (average 9 studies).....	45.2	13.8	31.4	.....	54.8	41.7	.....	6.9	6.2
Average 25 Japanese studies...	38.0	18.8	19.2	.....	62.0	47.5	.....	8.2	6.3
Average 185 American studies...	61.2	3.7	45.2	12.3	38.8	30.5	.....	2.0	6.3
Fat.									
Dietaries of professional men (average 8 studies).....	55.2	23.5	27.9	.....	44.8	26.4	.....	15.9	2.5
Dietaries of students (average 6 studies).....	54.8	22.1	32.7	.....	45.2	20.5	.....	19.3	5.4
Dietaries of men at hard work (average 2 studies).....	42.0	11.3	30.7	.....	58.0	20.5	.....	8.3	29.2
Dietaries in the navy (average 9 studies).....	69.5	8.2	56.2	5.1	30.5	21.5	.....	3.0	6.0
Average 25 Japanese studies...	59.2	16.7	39.5	.....	40.8	22.8	.....	11.4	6.6
Average 185 American studies...	91.6	.8	58.8	32.0	8.4	7.0	.....	.1	1.3

TABLE 60.—*Proportions of total protein, fat, and carbohydrates supplied by different groups of food materials—Continued.*

Group.	Proportion of total quantity in the diet supplied by—								
	Total animal food.	Fish.	Meats, eggs, etc.	Dairy products.	Total vegetable food.	Cereals.	Sugars and starches.	Legumes and their preparations.	Vegetables.
<i>Carbohydrates.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Dietaries of professional men (average 8 studies).....	0.3	.....	.....	0.3	99.7	87.1	6.1	1.7	4.8
Dietaries of students (average 6 studies).....	1.6	0.9	0.7	.....	98.4	91.6	1.1	1.3	4.4
Dietaries of men at hard work (average 2 studies).....	.5	.5	.....	.....	99.5	93.8	2.4	1.3	2.0
Dietaries in the navy (average 9 studies).....	.5	.....	.....	.5	99.5	82.9	6.3	1.9	8.4
Average 25 Japanese studies....	.7	.2	.....	.3	99.3	87.2	4.7	1.6	5.8
Average 185 American studies....	5.4	.1	.....	5.3	94.6	54.7	21.2	1.3	17.4

In the average of these 25 studies about 38 per cent of the total protein was derived from animal food, including meat, fish, some eggs, and a very small amount of dairy products in exceptional cases. Milk is not an ordinary article of diet in Japan, and is used but sparingly where it is used at all. Fish is the most important of the animal foods, supplying one to two thirds of all the animal protein in the diet. The remaining 62 per cent of the total protein was derived from vegetable foods, 48 per cent being supplied by cereals, 8 per cent by legumes, including the various preparations, and 6 per cent by vegetables. In a vegetable diet the proportion of the total protein of the diet that is obtained from cereals, legumes, etc., is of course much larger, but unfortunately in the reports of the dietaries of this nature the data given did not suffice for determining these factors.

The difference between the average figures for Japanese and American mixed diets in respect to the proportions of total protein derived from animal and vegetable foods is striking, the figures for the American diet being just the reverse of those for the Japanese diet. The proportion of total protein derived from fish and from legumes is relatively much larger, and that from meat much smaller, in the Japanese than in the American diet.

Of the total fat in the Japanese mixed diet, 59 per cent was supplied by animal foods and 41 per cent by vegetable foods. In the American diet about 92 per cent is from the former and only 8 per cent from the latter. It will be remembered that the total amount of fat in the Japanese mixed diet averages hardly a fifth of that in the American diet, and furthermore that the dairy products,

which furnish nearly a third of the total fat in the American diet, are practically unknown in the Japanese diet.

Practically the total amount of carbohydrates in the Japanese diet was supplied by vegetable foods, the most important source being cereals, which furnished more than 87 per cent of the whole. In the American diet a small proportion of the total carbohydrate in the diet is obtained in milk. In the latter diet only about 55 per cent of the total is derived from cereals, but this is compensated by a consumption of sugar that is nearly five times that in the Japanese diet.

It is to be especially noted that these data are for the ordinary Japanese mixed diet; that is, a diet containing both animal and vegetable foods. It is believed that for such a diet, among the industrial and professional classes in Japan, these figures give a fair representation of the actual distribution of the nutrients among the different groups of food materials considered. With how much accuracy these figures may be considered as representing the average Japanese dietary it is impossible to determine from the available data. A large part of the population of Japan lives almost entirely on a mixed vegetable diet. The dietaries of such people form an entirely separate class from what has been considered above, and should be studied separately. As has been already stated, 24 of the studies were those of vegetable mixed diet, but the data reported in these studies are not of such a character as to warrant drawing from them general estimates regarding the proportions of nutrients supplied by different food materials in dietaries of this class.

THE JAPANESE AS VEGETARIANS.

It is frequently stated that the Japanese are vegetarians. It would be interesting to determine to what extent this is true, but the data of the investigations here compiled do not afford opportunity for decision. The dietary studies were mostly with the class of people that make up the smaller part of the population. Very few studies were made with the classes of people that comprise the large majority. The amount and character of the investigations are therefore insufficient to warrant any definite conclusions regarding what might be called the national diet of the Japanese. At the same time, the available statistics afford some interesting deductions.

It has already been pointed out that the diets of the people in more comfortable circumstances contain an appreciable amount of animal food, and that those of the poorer classes contain practically none. Recent statistics, to which reference has previously been made (p. 18), show that during the year 1900 the amounts of animal food per capita available were as follows: Dressed meat 1.3, fresh fish 26.9, dried fish 2.5, and imported meat and fish 0.3 pounds.

The weights of fish include in part a certain proportion of inedible material, i. e., bones, etc., for which allowance would have to be made in estimating the actual amount of food material available. The figures will serve to indicate, however, what is perhaps the probable maximum consumption per capita of population, including children under 15 years of age and adults over 60 years of age. These figures are in striking contrast with those for other countries.

Most, if not all, of the meat used in Japan is consumed by the well-to-do people in large cities. The larger part of the fish is also used by people in comfortable circumstances, and especially in the coast regions. Methods of preserving fish are not yet highly developed, and for the rural population the high price prohibits the use of fish.

The rural population of the interior depends very largely or entirely upon a vegetable diet. Fish is eaten perhaps once or twice a month, and meat once or twice a year, if at all. The poorer working classes in the cities also use very little animal food. But the poorer classes in the city and the peasantry of the rural districts comprise nearly 75 per cent of the total population, and it is therefore safe to assume that this proportion lives chiefly or wholly upon vegetable diet. And this, it may be observed, means vegetarianism literally. The so-called lacto-vegetarianism is unknown in Japan. Cows are scarce, and milk and other dairy products are expensive, and such as are available are consumed almost entirely by the wealthier people in the cities.

In general, however, the Japanese are vegetarians from force of adverse financial circumstances, rather than from principle; and except in the case of a relatively small number of strict adherents to Buddhism, they eat animal foods whenever they can afford it. Even a certain sect of Buddhists that originated in Japan is very tolerant on this point and its followers do not hesitate to indulge in animal food when they can get it. That Buddhism has had a certain influence upon the life and dietary habits of the people, especially among the lower classes, is without question. They are indebted to Buddhist priests, either directly or indirectly, for the original methods of making the preparations of legumes, such as miso, natto, tofu, etc. (see p. 23), that are so prevalently used. These products are more palatable and assimilable than the untreated legumes, and form an important source of protein, as well as help to improve the flavor of a rather monotonous diet.

IMPORTANCE OF RICE IN THE JAPANESE DIET.

The common western conception of vegetarianism in Japan is that it means a rice diet. There is a very general popular belief that rice is the principal, if not practically the only, food of the

large majority of Japanese and other oriental people. As a matter of fact, though rice is a very important article of diet, and is eaten in relatively large quantity where it can be afforded, it is by no means the only food material, nor is it in all cases the principal cereal. Among the poorer classes in certain districts rice is considered a luxury, being too expensive for regular consumption, and is eaten only on special occasions, such as festivals, or when entertaining guests. Barley and millet are largely used in place of rice as the regular cereal of the diet. In other districts part of the rice is replaced by such cereals, mixtures of rice and barley in various proportions being common. Buckwheat is also used. Some of the dietary studies afford interesting information concerning the importance of rice in the diet, as illustrated by the proportion of the total protein, fat, and carbohydrates of the diet supplied by rice. These data are summarized in the following table:

TABLE 61.—*Proportion of total nutrients of the diet of Japanese supplied by rice.*

Group.	Quantity of rice per man per day.	Proportion of total nutrients supplied by rice.		
		Protein.	Fat.	Carbohy- drates.
	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dietaries of professional men (average 8 studies).....	513	47.4	28.7	87.2
Dietaries of students (average 7 studies).....	631	54.9	19.5	91.8
Dietaries of men at hard work (average 2 studies).....	1,170	58.4	18.5	93.7
Dietaries of soldiers (average 7 studies).....	643	56.8	21.2	87.2
Average 24 studies.....		53.2	23.0	89.5
Dietaries in the navy (average 9 studies).....	388	21.5	10.4	52.1

From these data it is very apparent that though rice was used in large amounts it is far from being the only food used. The amount of rice consumed varied among the different classes studied, as would be expected. The people at hard work required more energy-producing food, and consumed larger amounts of rice, i. e., the available and palatable cereal food, than those whose muscular activity was less. The amount consumed varied also according to the amounts of other cereals than rice that were used. For example, in the navy ration, of which bread formed a part, the average quantity of rice per day was 388 grams, whereas in the army, with the soldiers who used the rice ration, it was 643 grams. Among the professional men the average daily consumption was 513 grams of rice, while in students' dietaries a somewhat larger amount, 631 grams, was used. The men at hard work averaged 1,170 grams of rice per day, or more than double the quantity consumed by professional men. It would be fair to estimate that from 500 to 650 grams of rice are used daily by the men of moderate muscular activity.

The figures in the table indicate that in the average of these studies about 53 per cent of the total protein of the diet, 23 per cent of the

total fat, and 89 per cent of the total carbohydrates were furnished by rice. It is to be noted in this connection that these results were selected from those of studies which were believed to represent the ordinary type of the Japanese mixed diet in which rice was the principal cereal used. In dietaries where rice is substituted by barley or bread to the extent of 30 or 40 per cent, or even more, as is done in certain special cases, the proportion of nutrients supplied by rice must naturally be decreased. A good illustration of this is found in the navy ration, where considerable amounts of bread are used daily. Taking the average of 9 such studies, total cereals furnished 42 per cent of the protein, 22 per cent of the fat, and 83 per cent of the carbohydrates, while rice supplied 22 per cent of the protein, 10 per cent of the fat, and 52 per cent of the carbohydrates.

It thus appears that in these navy rations the cereals or cereal products other than rice furnished about as much nutrients as the rice.

In dietaries of a purely vegetable nature rice is of considerable more importance than is indicated above. This may be illustrated by the results in dietary studies Nos. 94 and 99. In study No. 94 a strictly vegetable diet was used, rice being the only cereal. In study No. 99 a small amount of salted fish was eaten, but rice was in this case also the only cereal.

In the first-mentioned study, No. 94, rice furnished 93 per cent of the protein, 96 per cent of the fat, and 95 per cent of the carbohydrates. In the other study, No. 95, rice furnished 78 per cent of the protein, 65 per cent of the fat, and 96 per cent of the carbohydrates.

These figures afford only a general indication of the importance of rice in a vegetable diet. Of more than 20 vegetable dietary studies summarized in this compilation only a very few were believed to be typical of such a diet under normal circumstances, and in these few typical vegetable dietaries unfortunately it was not possible to determine the proportion of nutrients supplied by rice separately from other cereal products.

It has been stated above that in communities where such vegetable diets prevail use is made of a number of other cereals, such as barley, buckwheat, millets, etc., to a considerable extent. The statistics collated by the Department of Agriculture and Commerce, Tokyo, for the year 1880, showing the proportions of different vegetable foods consumed by the Japanese, are quite interesting. Data were collected from different provinces, and from these the following average figures were derived as applicable to the country as a whole: Of the total vegetable food, rice formed 53 per cent, barley and wheat 27 per cent; millets, buckwheat, legumes, etc., 13.9 per cent; tubers and other vegetables, 6 per cent; fruits, 0.05 per cent, and sea algæ, 0.05 per cent. While these figures refer only to the total vegetable foods,

they afford a sufficient indication of the importance of rice in the Japanese national diet, and show at the same time that other cereals form by no means an unimportant part of the whole.

IMPORTANCE OF LEGUMES IN THE JAPANESE DIET.

It has been explained (p. 24) that certain legumes are eaten to some extent simply cooked in their natural state, but that various preparations of the soy bean—miso, shoyu, tofu, etc.—are indispensable articles of diet in Japan. Some are used as food materials, and others as flavoring materials, to increase the palatability of the diet; but the latter also add to its nutritive value, and thus serve a double purpose. The data of a number of the studies afford opportunity for estimating the relative importance of the legumes and their preparations in ordinary mixed diet. This is shown by the figures in the following table; showing what proportions of the total nutrients of the diet was supplied by these materials in the average of the studies with different classes of people.

TABLE 62.—*Proportion of total nutrients of the diet supplied by legumes and their preparations.*

Group.	Protein.	Fat.	Carbo- hydrates.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dietaries of professional men (average 8 studies)	9.3	15.9	1.7
Dietaries of students (average 6 studies)	9.4	19.3	1.3
Dietaries of men at hard work (average 2 studies)	6.0	8.3	1.3
Dietaries in the navy (average 9 studies)	6.9	3.0	1.9
Average 25 studies	8.2	11.4	1.6

According to these average figures the legumes furnished a very noticeable proportion of the protein (8 per cent) and fat (11 per cent) of the diet. The larger proportions were those in the dietaries of the professional men and students; and these were probably more typical than the others of the ordinary Japanese mixed diet. These figures may therefore be taken as a fair indication of the relative importance of the legumes and their preparations in such a diet. Possibly in a purely vegetable diet the figures would be larger, but the reported data of the studies with such diets do not afford opportunity for settling this point.

DIGESTIBILITY OF JAPANESE FOOD MATERIALS.

In the study of the nutrition of man in Japan much attention has been given to determinations of the proportions of the different nutrients in Japanese food materials that are actually digested and utilized by the body. So far as can be learned the first series of digestion experiments with Japanese food materials was conducted by Professor Osawa at the Physiological Institute of Tokyo University in

1885, and later additional experiments were conducted in the laboratory under his direction. In the medical bureau of the army the question of substituting barley or bread for rice received very serious consideration. Oi made a series of comparative digestion experiments with rice rations and rice-barley rations in 1886. Later, in 1889, a more thorough study was made by Mori, Oi, and Iishima, to determine the comparative digestibility of rice rations, barley-rice rations, and European or bread rations. A large number of digestion experiments with single food materials was conducted in the laboratory of the Army Medical College at Tokyo during the years 1896-1901. In connection with dietary studies, digestion experiments were made by Kellner, Kumagawa, Tsuboi, Amaya, and others, in different institutions with which they were connected. A list of the digestion experiments with Japanese food materials is here given in the order in which they were published. The serial numbers in the first column are those by which the experiments are hereafter designated.

TABLE 63.—*List of digestion experiments.*

Serial No.	Date of publication.	Observer.	Subject.	Duration (days).	Food.	Accompanying dietary and metabolism experiments.
1	1887	Osawa and Ueda.	Laboratory assistant.	4	Barley.	Nitrogen metabolism experiment No. 1.
2	1887	do.	do.	4	do.	Nitrogen metabolism experiment No. 2.
3	1887	do.	do.	3	do.	Nitrogen metabolism experiment No. 3.
4	1887	do.	do.	3	Rice.	Nitrogen metabolism experiment No. 4.
5	1887	do.	do.	3	do.	Nitrogen metabolism experiment No. 5.
6	1887	do.	Student.	3	Beans, dried.	Nitrogen metabolism experiment No. 6.
7	1887	do.	do.	3	do.	Nitrogen metabolism experiment No. 7.
8	1887	do.	Laboratory assistant.	2	Tofu.	Nitrogen metabolism experiment No. 8.
9	1887	do.	do.	3	Porgy.	Nitrogen metabolism experiment No. 9.
10	1887	do.	do.	3	Salmon.	Nitrogen metabolism experiment No. 10.
11	1887	do.	do.	3	Herring, dried.	Nitrogen metabolism experiment No. 11.
12	1887	do.	do.	3	Cod, dried.	Nitrogen metabolism experiment No. 12.
13	1887	Kellner and Y. Mori.	Chemist.	3	Mixed vegetable and animal diet.	Dietary study No. 19 and nitrogen metabolism experiment No. 13.
14	1887	do.	do.	3	do.	Dietary study No. 20 and nitrogen metabolism experiment No. 14.
15	1887	do.	do.	3	Mixed vegetable diet with barley.	Dietary study No. 21 and nitrogen metabolism experiment No. 15.
16	1888	Suchi.	Observer.	7	Rice and tofu.	Nitrogen metabolism experiment No. 16.
17	1888	do.	do.	6	Rice, tofu, and oil.	Nitrogen metabolism experiment No. 17.
18	1888	Osawa.	Medical student.	3	Rice and tofu.	Nitrogen metabolism experiment No. 18.
19	1889	Tsuboi.	Man.	2	Glutinous rice cake.	Nitrogen metabolism experiment No. 19.
20	1889	Kumagawa.	Observer.	13	Mixed vegetable and animal diet.	Dietary study No. 27 and nitrogen metabolism experiment No. 20.
21	1889	do.	do.	5	do.	Dietary study No. 28 and nitrogen metabolism experiment No. 21.
22	1889	do.	do.	5	Mixed vegetable diet.	Dietary study No. 29 and nitrogen metabolism experiment No. 22.
23	1889	do.	do.	9	do.	Dietary study No. 30 and nitrogen metabolism experiment No. 23.
24	1890	Nakasawa.	do.	3	Rice and vegetables.	Nitrogen metabolism experiment No. 24.
25	1890	Tsuboi and Murata.	Physician.	3	Mixed vegetable and animal diet.	Dietary study No. 31 and nitrogen metabolism experiment No. 25.
26	1890	do.	Laboratory assistant.	3	do.	Dietary study No. 32 and nitrogen metabolism experiment No. 26.
27	1890	do.	Medical student.	3	do.	Dietary study No. 33 and nitrogen metabolism experiment No. 27.
28	1891	Amaya and Kirisawa.	Laboratory assistant.	10	do.	Dietary study No. 35 and nitrogen metabolism experiment No. 28.
29	1891	do.	Physician.	7	do.	Dietary study No. 36 and nitrogen metabolism experiment No. 29.
30	1891	do.	Laboratory assistant.	7	do.	Dietary study No. 37 and nitrogen metabolism experiment No. 30.

TABLE 63—*List of digestion experiments—Continued.*

Serial No.	Date of publication.	Observer.	Subject.	Duration (days).	Food.	Accompanying dietary and metabolism experiments.
31	1891	Amaya and Kirisawa.	Laboratory assistant.	6	Mixed vegetable and animal diet.	Dietary study No. 37a and nitrogen metabolism experiment No. 31.
32	1891	do.	do.	10	Mixed vegetable diet, with legumes.	Dietary study No. 38 and nitrogen metabolism experiment No. 32.
33	1892	do.	do.	5	Mixed vegetable diet.	Dietary study No. 39 and nitrogen metabolism experiment No. 33.
34	1892	do.	do.	7	do.	Dietary study No. 40 and nitrogen metabolism experiment No. 34.
35	1892	do.	Physician.	6	do.	Dietary study No. 41 and nitrogen metabolism experiment No. 35.
36	1892	do.	do.	6	do.	Dietary study No. 42 and nitrogen metabolism experiment No. 36.
37	1892	Taniguchi.	Laboratory servant.	2	Rice and beef extract.	Dietary study No. 59 and nitrogen metabolism experiment No. 37.
38	1892	do.	do.	4	Rice and pickles.	Dietary study No. 60 and nitrogen metabolism experiment No. 38.
39	1892	do.	do.	10	Rice and miso.	Dietary study No. 61 and nitrogen metabolism experiment No. 39.
40	1892	do.	do.	10	Rice and vegetables.	Dietary study No. 62 and nitrogen metabolism experiment No. 40.
41	1892	do.	do.	10	do.	Dietary study No. 63 and nitrogen metabolism experiment No. 41.
42	1892	do.	do.	10	do.	Dietary study No. 64 and nitrogen metabolism experiment No. 42.
43	1892	do.	do.	5	do.	Dietary study No. 65 and nitrogen metabolism experiment No. 43.
44	1892	Oi.	Military nurses.	3	Rice and fish.	Dietary study No. 67 and nitrogen metabolism experiment No. 44.
45	1892	do.	do.	3	Rice and tofu.	Dietary study No. 68 and nitrogen metabolism experiment No. 45.
46	1892	do.	do.	3	Rice and vegetables.	Dietary study No. 69 and nitrogen metabolism experiment No. 46.
47	1892	do.	do.	3	Rice, barley, and meat.	Dietary study No. 70 and nitrogen metabolism experiment No. 47.
48	1892	do.	do.	3	Rice, barley, and fish.	Dietary study No. 71 and nitrogen metabolism experiment No. 48.
49	1892	do.	do.	3	Rice, barley, and tofu.	Dietary study No. 72 and nitrogen metabolism experiment No. 49.
50	1892	do.	do.	3	Rice, barley, and vegetables.	Dietary study No. 73 and nitrogen metabolism experiment No. 50.
51	1892	R. Mori, Oi, and Ushima.	Soldier.	8	Army, rice ration.	Dietary study No. 74 and nitrogen metabolism experiment No. 51.
52	1892	do.	do.	8	do.	Dietary study No. 75 and nitrogen metabolism experiment No. 52.

53	1892	do.	do.	8	do.	Dietary study No. 53.	No. 76 and nitrogen metabolism experi-
54	1892	do.	do.	8	do.	Dietary study No. 54.	ment No. 77 and nitrogen metabolism experi-
55	1892	do.	do.	8	do.	Dietary study No. 55.	ment No. 78 and nitrogen metabolism experi-
56	1892	do.	do.	8	do.	Dietary study No. 56.	ment No. 79 and nitrogen metabolism experi-
57	1892	do.	do.	8	Army, rice-barley ration.	Dietary study No. 57.	ment No. 80 and nitrogen metabolism experi-
58	1892	do.	do.	8	do.	Dietary study No. 58.	ment No. 81 and nitrogen metabolism experi-
59	1892	do.	do.	8	do.	Dietary study No. 59.	ment No. 82 and nitrogen metabolism experi-
60	1892	do.	do.	8	do.	Dietary study No. 60.	ment No. 83 and nitrogen metabolism experi-
61	1892	do.	do.	8	do.	Dietary study No. 61.	ment No. 84 and nitrogen metabolism experi-
62	1892	do.	do.	8	do.	Dietary study No. 62.	ment No. 85 and nitrogen metabolism experi-
63	1892	do.	Military nurse.	8	Army, barley ration.	Dietary study No. 63.	ment No. 86 and nitrogen metabolism experi-
64	1892	do.	Soldier.	8	Army, bread ration.	Dietary study No. 64.	ment No. 87 and nitrogen metabolism experi-
65	1892	do.	do.	8	do.	Dietary study No. 65.	ment No. 88 and nitrogen metabolism experi-
66	1892	do.	do.	8	do.	Dietary study No. 66.	ment No. 89 and nitrogen metabolism experi-
67	1892	do.	do.	8	do.	Dietary study No. 67.	ment No. 90 and nitrogen metabolism experi-
68	1892	do.	do.	8	do.	Dietary study No. 68.	ment No. 91 and nitrogen metabolism experi-
69	1892	do.	do.	8	do.	Dietary study No. 69.	ment No. 92 and nitrogen metabolism experi-
70	1892	Ol.	Military nurse.	12	Army, rice ration.	Dietary study No. 70.	ment No. 93 and nitrogen metabolism experi-
71	1892	do.	do.	12	Army, bread ration.	Dietary study No. 71.	ment No. 94 and nitrogen metabolism experi-
72	1893	Kumagawa and Kaneda.	Laboratory assistant.	8	Rice and milk.		
73	1893	do.	do.	6	Rice and "Health"		
74	1894	R. Mori.	Army surgeon.	5	Glutinous rice cake, dried.		
75	1896	Washtsu and Uki.	Laboratory servant.	3	Buckwheat.		
76	1896	Kawanishi.	do.	3	do.		
77	1896	do.	do.	3	Macaroni.		
78	1896	do.	do.	3	do.		
79	1893	do.	do.	3	Vermicelli.		
80	1896	do.	do.	3	do.		
81	1899	Kano and Iishima.	do.	1	Pumpkin.		
82	1899	do.	Army surgeon.	1	Taro.		
83	1899	do.	do.	1	<i>Dioscorea</i> sp.		
84	1899	do.	Laboratory servant.	1	<i>Stachys sieboldi</i> .		
85	1899	do.	do.	1	Potato.		

TABLE 63.—*List of digestion experiments—Continued.*

Serial No.	Date of publication.	Observer	Subject.	Duration (days).	Food.	Accompanying dietary and metabolism experiments.
86	1899	Kano and Ishima	Army surgeon	1	Lily bulb	
87	1899	do.	Laboratory servant	1	Arrowhead	
88	1899	do.	Army surgeon	1	Lotus rhizome	
89	1899	do.	Laboratory servant	1	Fu	
90	1899	do.	do.	1	do.	
91	1899	do.	do.	1	Dry bread	
92	1899	do.	Army surgeon	1	Tofu	
93	1899	do.	do.	1	Tofu cake	
94	1899	do.	do.	1	Yuba	
95	1899	do.	do.	1	Konnyaku	
96	1899	do.	do.	1	Starch	
97	1899	do.	do.	1	do.	
98	1899	do.	Laboratory servant	1	Gourd, dried	
99	1899	do.	do.	3	Sweet potato	
100	1899	do.	do.	3	do.	
101	1899	Nagao	Army surgeon	4	Army, rice-barley ration	
102	1901	Ito and Washitsu	Military nurse	3	Rice gruel	
103	1901	do.	do.	3	do.	
104	1901	do.	do.	3	do.	
105	1902	Murai and Kasana	Army surgeon	1	Eggplant	
106	1902	do.	do.	1	Dried fern	
107	1902	do.	do.	1	Taro stem, dried	
108	1902	do.	do.	1	Gourd	
109	1902	do.	do.	1	Carrots	
110	1902	do.	do.	1	Radishes	
111	1902	do.	Laboratory servant	1	Burdock	
112	1902	do.	Army surgeon	1	Dried mushroom	
113	1902	do.	do.	5	Rice	
114	1902	do.	do.	3	Rolled barley	
115	1902	do.	do.	1	Marine algae	
116	1902	do.	do.	1	do.	
117	1902	do.	do.	4	Cracked barley and rice	
118	1902	do.	do.	3	Marine algae and rice	
119	1902	do.	do.	2	Poultice and rice	
120	1902	do.	do.	2	Shellfish, and rice	
121	1902	do.	do.	3	Dried fish and rice	
122	1902	do.	do.	3	do.	
123	1902	do.	do.	3	Kamaboko and rice	
124	1902	do.	do.	3	do.	
125	1902	do.	do.	2	Bamboo shoot and rice	

The total number of digestion experiments found on record in publications issued between the years 1887 and 1902, inclusive, is 125. The subjects were all men, most of them in professional or military life, and in each experiment, except in Nos. 44-50 and 70-71, there was but one subject. The experiments covered from one to twelve days. In 54 of them only one food material was used, in the remainder there were different combinations of food materials, in some cases only two, and in other cases a varied diet, either wholly vegetable, or both vegetable and animal food. Many of the digestion experiments were parts of investigations that included also dietary studies or nitrogen metabolism experiments, or both. These are indicated in the last column of the table above.

In 27 of the experiments the digestibility of the protein only was determined. These are included in a separate division of this section under the heading "incomplete experiments."

The methods of estimating the digestibility of nutrients followed by different investigators were essentially uniform, namely, the determination of the amounts of nutrients in the food actually eaten and of the corresponding ingredients in the feces pertaining to it. The difference between the amount in the food and that in the feces was taken as a measure of the amount of a given ingredient digested. The amount digested divided by the total amount in the food, and multiplied by 100, gives the percentage digested, or the coefficient of digestibility.

The methods of separating the feces for the experimental diet from that of the diet, preceding and following the experiment were not uniform. Earlier investigators used beef, milk, or yolk of eggs for this purpose, but later lampblack, red mungo bean, and other substances were employed. The methods of analysis of feces were essentially the same as those for analysis of food material, described on page 38. The heat of combustion of feces and of urine was not determined in any case.

The composition of the food materials analyzed in connection with the digestion experiments, when reported, has been included in Table 6, and need not be repeated here. The reference numbers in the tables of the experiments, which correspond with those in the first column of Table 6, serve to indicate the analyses used in computing the quantities of nutrients in the food.

The composition of the feces was reported in only 63 of the experiments. These data are given in the following table. In the other experiments, although the feces were analyzed in each case, only the calculated amounts of ingredients were reported.

TABLE 64.—Composition of feces of Japanese digestion experiments.

Whence obtained.	Water.	Nitrogen.	Protein (N×6.25).	Fat.	Nitrogen- free extract.	Crude fiber.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Experiment No. 1		6.064	37.90	11.12	32.52	8.59	9.89
Experiment No. 2		6.337	39.61	16.71	31.39		12.29
Experiment No. 3		6.408	40.05	16.28	22.66	10.95	10.06
Experiment No. 4		10.648	66.55	10.87	15.81		6.77
Experiment No. 5		10.532	65.83	9.23	19.73		5.21
Experiment No. 6		6.159	38.49	30.03	16.21	7.67	7.60
Experiment No. 7		6.101	38.13	34.38	11.81	7.73	7.95
Experiment No. 8		5.584	34.90	9.22	29.32		26.56
Experiment No. 9		8.625	53.91	13.29	11.41		21.39
Experiment No. 10		8.120	50.75	21.14	11.82		16.29
Experiment No. 11		10.516	65.73	11.00	13.11		10.16
Experiment No. 12		10.520	65.75	9.55	10.13		14.57
Experiment No. 16		6.48	40.53	10.26	34.06		15.15
Experiment No. 17		6.795	42.47	33.77	11.64		12.12
Experiment No. 24		8.76	54.75	11.03	23.77		10.45
Experiment No. 72	75.26	2.327	14.54	3.00	3.60		3.60
Experiment No. 73	75.96	2.559	16.00	2.28	3.26		2.50
Experiment No. 76	6.77	5.228	32.68	5.07	40.20		15.28
Experiment No. 77	5.52	5.929	37.06	5.02	40.46		11.94
Experiment No. 78	2.75	7.140	44.62	5.16	32.27		15.20
Experiment No. 79	10.18	6.452	40.33	4.50	31.12		13.87
Experiment No. 80	3.05	6.615	41.34	4.73	34.58		16.30
Experiment No. 81	86.80	.793	4.96	1.42	3.89	.56	2.37
Experiment No. 82	85.40	.861	5.38	1.37	4.70	.87	2.28
Experiment No. 83	84.68	1.133	7.08	1.33	3.47	1.17	2.27
Experiment No. 84	83.89	.895	5.59	1.18	6.02	.84	2.48
Experiment No. 85	87.57	.790	4.94	1.16	3.91	.49	1.93
Experiment No. 86	67.28	1.941	12.13	3.21	13.85	1.08	2.45
Experiment No. 87	89.63	.492	3.07	.68	4.04	.59	1.99
Experiment No. 88	91.06	.403	2.52	.52	3.45	1.33	1.12
Experiment No. 89	81.54	1.447	9.04	1.47	7.21	.24	.50
Experiment No. 90	75.91	1.375	8.59	1.79	11.13	.49	2.09
Experiment No. 91	83.34	1.145	7.16	1.50	5.47	.37	2.16
Experiment No. 92	79.59	1.744	10.90	3.61	.39		5.51
Experiment No. 93	63.29	2.417	15.11	3.77	9.65	2.63	5.55
Experiment No. 94	43.89	4.034	25.21	6.24	13.78	1.65	9.23
Experiment No. 95	81.27	.800	5.00	1.51	8.93	.89	2.40
Experiment No. 96	80.44	.640	4.00	2.26	12.30		1.00
Experiment No. 97	81.58	1.030	6.44	2.21	9.01		.76
Experiment No. 98	78.93	1.054	6.59	2.04	8.21	1.38	2.85
Experiment No. 99	4.25		34.37	7.20	43.20		10.98
Experiment No. 100	4.17		40.94	9.88	34.77		10.24
Experiment No. 105	56.59		18.14	3.19	12.57	2.85	6.66
Experiment No. 106	76.99		9.58	2.17	7.97	.85	2.44
Experiment No. 107	65.55		10.31	3.26	6.28	9.75	4.85
Experiment No. 108	67.38		15.53	3.58	4.56	3.77	5.18
Experiment No. 109	88.54		5.28	1.42	2.40	.60	1.76
Experiment No. 110	83.47		7.99	2.25	2.76	.82	2.51
Experiment No. 111	76.17		12.27	2.03	4.20	1.87	3.46
Experiment No. 112	77.87		9.33	2.05	6.18	.96	2.41
Experiment No. 113	59.88		22.21	5.49	6.20	2.20	4.02
Experiment No. 114	66.73		11.92	6.58	8.01	2.05	4.71
Experiment No. 115	81.14		1.17	.83	3.21	9.82	3.83
Experiment No. 116	61.47		5.03	6.87	16.65	2.08	7.90
Experiment No. 117	79.43		12.05	4.12	.93	1.42	2.05
Experiment No. 118	79.52		11.36	2.40	3.11	1.14	2.47
Experiment No. 119	84.18		6.52	1.13	4.50	1.57	2.10
Experiment No. 120	64.29		16.87	7.69	7.35		3.80
Experiment No. 121	71.34		16.97	5.17	2.83		3.69
Experiment No. 122	54.40		20.17	5.81	11.33		8.29
Experiment No. 123	74.17		15.80	4.23	2.72		3.08
Experiment No. 124	67.75		17.89	5.39	4.92		4.05
Experiment No. 125	87.19		7.32	1.43	1.62	.90	1.54

NOTE.—Compositions of feces of experiments Nos. 1-12, 16, 17, and 24, are on water-free basis.

DIGESTION EXPERIMENTS.

The details of the digestion experiments follow. In all cases methods are described and such other data as seemed necessary are quoted. In the majority of cases the results were given in three decimal places in the original reports; but in compiling the data only two have been used, the second decimal figure being increased by one if the third in the original was five or over.

DIGESTION EXPERIMENTS WITH CEREALS, LEGUMES, AND FISH (Nos. 1-12).

This series of experiments was made by Osawa and Ueda at the Physiological Institute, Tokyo, in 1885, and the results were published in 1887.

The food materials were those in common use in Japan. The barley, however, was not the cracked barley that is generally used, but the whole grain simply cleaned, i. e., with the outer husk removed, though the cleaning process was not entirely satisfactory. Rice and barley were cooked in water and eaten with certain condiments; most of the other materials were cooked in shoyu. Water and weak tea infusion were freely allowed as beverages.

For separation of the feces, beef was used as a marker in experiments Nos. 1 to 5, and 8, and egg yolk in all the other tests. The material was eaten about 18 hours before the first meal of the experiment and with the meal immediately following it. Defecation occurred usually at intervals of about 24 hours, though during experiments Nos. 1, 6, and 7 the intervals were decidedly shorter, averaging about 11 hours in experiment No. 1, 7 hours in experiment No. 6, and 14 hours in experiment No. 7.

In experiment No. 9 the subject had difficulty in eating the fish on the third day, and a small amount of vinegar was used to render it more palatable. Fibers of muscular and connective tissue of fish flesh were detected in the feces.

In the feces from experiment No. 11, fibers of muscular tissue were detected under the microscope, and some small pieces of the undigested fish could be detected even without its aid.

In experiment No. 12 small pieces of undigested material were also detected in the feces. Chemical tests for dextrin and sugar in the feces were made in this experiment, and also in experiment No. 11, with negative results, indicating that the carbohydrates of the ame used in cooking had been completely digested. It would therefore appear justifiable to neglect the nutrients of ame in computing the results of the experiment.

Samples of feces and of all food materials, except mustard and pepper, were analyzed; the composition of the latter was taken from König's compilation. In making the analyses, water was determined by drying the substance at 110° C. until constant weight was obtained; nitrogen was determined by the Will-Varrentrapp method, and protein was computed as $N \times 6.25$. In the case of fish the result thus obtained does not always agree very closely with that estimated by difference. Fat was determined by extracting with ether in a Soxhlet apparatus. Crude fiber was determined by treating the substance previously freed from fat and starch with a mixture of nitric acid and potassium chlorid, filtering through a previously weighed filter, washing and drying; the weight of ash in the residue

was then determined and deducted. Ash was determined by igniting in a platinum dish, and carbohydrates were estimated by difference. The data regarding the analyses of food are included in Table 6.

Urine was collected in each experiment, and the nitrogen and sodium chlorid in it were determined, Liebig's method being used for nitrogen.

In the tables of the original report the figures for nitrogen were used instead of those for protein; but for the sake of uniformity with the data of other experiments, the figures for protein ($N \times 6.25$) have been included in Table 65, which gives the results of the experiments.

Protein and carbohydrates in shoyu were assumed by the investigator to be completely digested and were not included in the total nutrients of the food eaten, though the mineral matters of shoyu were included in the totals. The total protein ($N \times 6.25$) in beef extract and beef soup were included in the total for the diet without regard to the different forms of nitrogenous material. It would perhaps be better to discard rather than to include these, but since the results of these experiments have been often quoted it seems desirable to retain the original figures in the present compilation.

Digestion experiment with barley^a (No. 1).—This experiment continued four days, beginning with breakfast, March 27, 1885. The subject, K. U., was a laboratory assistant 23 year old, weighing 53.59 kilograms at the beginning of the experiment and 52.15 kilograms at the end. The diet consisted chiefly of cooked barley, though a considerable amount of beef soup was also included. For several days preceding the experiment the diet of the subject consisted of barley and rice, 7 parts of the former to 2 parts of the latter.

During the experiment the subject eliminated 5,130 cubic centimeters of urine, containing 43.49 grams of nitrogen and 55 grams of sodium chlorid.

Digestion experiment with barley^b (No. 2).—This experiment continued four days, beginning with breakfast, May 12, 1885, though in addition to the experiment proper there were several days of preliminary observation. The subject was the same as in the preceding experiment, weighing 52.78 kilograms at the beginning and 52.54 kilograms at the end of the experiment. The diet consisted chiefly of cooked barley, with several kinds of accessory foods.

During the experiment the subject eliminated 5,675 cubic centimeters of urine, containing 50.27 grams of nitrogen and 49.61 grams of sodium chlorid.

^a Chugai Iji Shimpo (Med. News, foreign and domestic), Tokyo, 1887, No. 173, p. 6.

^b Ibid., p. 11.

Digestion experiment with barley^a (No. 3).—This experiment continued four days, beginning with breakfast May 27, 1885. The subject, who was the same as in the preceding experiment, weighed 53.58 kilograms at the beginning and 50.88 kilograms at the end of the experiment. The diet consisted practically of cooked barley, with shoyu and mustard.

During this experiment the subject eliminated 3,680 cubic centimeters of urine, containing 44.57 grams of nitrogen and 25.15 grams of sodium chlorid.

Digestion experiment with rice^b (No. 4).—The experiment continued three days, beginning October 6, 1885. The subject, the same as in the preceding experiments, weighed 51.64 kilograms at the beginning and 51.37 kilograms at the end of the experiment. The diet consisted principally of cooked rice, with some shoyu and beef extract.

During this experiment the subject eliminated 5,010 cubic centimeters of urine, containing 27.96 grams of nitrogen and 16.84 grams of sodium chlorid.

Digestion experiment with rice^c (No. 5).—This experiment continued three days, October 20–22, 1885. The subject, the same as in the preceding experiments, weighed 51.19 kilograms at the end of the experiment. The diet consisted chiefly of cooked rice, with some shoyu and beef extract.

During this experiment the subject eliminated 4,120 cubic centimeters of urine, containing 29.7 grams of nitrogen and 16.07 grams of sodium chlorid.

Digestion experiment with dried beans^d (No. 6).—This experiment continued three days, September 15–17, 1885. The subject, J. M., was a medical student, weighing 47.85 kilograms at the beginning and 46.31 kilograms at the end of the experiment. The diet consisted of cooked dried beans (outer skin not removed), eaten with a considerable amount of sugar and some shoyu. The experiment was preceded by a preliminary period of four days.

During this experiment the subject eliminated 3,015 cubic centimeters of urine, containing 51.78 grams of nitrogen and 38.58 grams of sodium chlorid.

Digestion experiment with dried beans^e (No. 7).—This experiment continued three days, October 13–15, 1885. The subject was the same as in experiment No. 6. He weighed 48.31 kilograms at the beginning and 46.31 kilograms at the end of the experiment. The

^a Chugai Iji Shimpo (Med. News, foreign and domestic), Tokyo, 1887, No. 174, p. 12.

^b Ibid., No. 175, p. 16.

^c Ibid., No. 175, p. 21.

^d Ibid., No. 176, p. 8.

^e Ibid., No. 176, p. 15.

diet was like that of experiment No. 6, cooked dried beans (outer skin not removed) with a considerable amount of sugar and some shoyu and beef extract.

During this experiment the subject eliminated 2,160 cubic centimeters of urine, containing 33.96 grams of nitrogen and 18.72 grams of sodium chlorid.

Digestion experiment with tofu^a (No. 8).—This experiment continued two days, October 28–29, 1885. The subject, K. U. (same as in experiments Nos. 1–5 and 9–12), weighed 51.45 kilograms at the beginning and 49.36 kilograms at the end of the experiment. The diet consisted of tofu, with some shoyu and starch.

During this experiment the subject eliminated 3,290 cubic centimeters of urine, containing 66.37 grams of nitrogen and 20.32 grams of sodium chlorid.

Digestion experiment with porgy^b (No. 9).—This experiment continued three days, November 9–11, 1885. The subject, K. U., weighed 51.71 kilograms at the beginning of the experiment and 50.33 kilograms at the end. The diet consisted of fish (porgy), with some shoyu.

During this experiment the subject eliminated 6,100 cubic centimeters of urine, containing 106.36 grams of nitrogen and 31.66 grams of sodium chlorid.

Digestion experiment with raw salmon^c (No. 10).—This experiment continued three days, November 24–26, 1885. The subject, K. U., weighed 52.33 kilograms at the beginning of the experiment and 51.11 kilograms at the end. The diet consisted of raw salmon, with some shoyu.

During this experiment the subject eliminated 6,490 cubic centimeters of urine, containing 125.38 grams of nitrogen and 17.49 grams of sodium chlorid.

Digestion experiment with fried herring^d (No. 11).—This experiment continued three days, December 9–11, 1885. The subject, K. U., weighed 53.81 kilograms at the beginning of the experiment and 51.78 kilograms at the end. The diet consisted of fried herring, shoyu, and ame. The fish was soaked in water, the skin, bones, etc., removed, and the flesh was then well washed and cooked with shoyu and ame.

During this experiment the subject eliminated 4,650 cubic centimeters of urine, containing 104.72 grams of nitrogen and 24 grams of sodium chlorid.

Digestion experiment with dried cod^e (No. 12).—This experiment continued three days, December 22–24, 1885. The subject, K. U.,

^a Chugai Iji Shimpō (Med. News, foreign and domestic), Tokyo, 1887, No. 177, p. 16.

^b Ibid., No. 178, p. 21.

^c Ibid., No. 179, p. 25.

^d Ibid., No. 180, p. 14.

^e Ibid., No. 180, p. 18.

weighed 53.03 kilograms at the beginning and 49.60 kilograms at the end of the experiment. The diet consisted of dried codfish, shoyu, and ame. The fish was soaked in water, the skin, bones, etc., removed, and the flesh then cooked.

During this experiment the subject eliminated 1,360 cubic centimeters of urine, containing 114.55 grams of nitrogen and 34.50 grams of sodium chlorid.

TABLE 65.—Results of digestion experiments Nos. 1-12.

Anal- ysis ref- er- ence No.	Kind of food.	Weight of ma- terial.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 1.</i>						
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
37	Barley, cooked (water-free).....	1,714.7	187.4	20.4	1,484.5	66.5	22.4
18	Beef soup.....	781.4	20.5		1.7		6.4
122	Pepper.....	20.0	2.4	1.8	11.3	2.9	.9
	Salt.....	51.9					51.9
	Total.....	2,568.0	210.3	22.2	1,497.5	69.4	81.6
	Feces (water-free).....	331.9	125.8	36.9	136.5	28.5	32.7
	Amount digested.....		84.5		1,361.0	40.9	48.9
	Per cent digested.....		40.2		90.9	58.9	59.9
	<i>Experiment No. 2.</i>						
37	Barley, cooked (water-free).....	1,646.3	179.9	19.6	1,425.3		21.5
16	Beef extract.....	20.0	8.6		2.4		2.8
80	Shoyu.....	180.0					30.4
121	Mustard.....	5.0	1.3	1.5	1.6		.2
122	Pepper.....	6.8	.8	.6	3.9		.3
	Total.....	1,858.1	190.6	21.7	1,433.2		55.2
	Feces (water-free).....	231.7	91.7	38.7	72.8		28.5
	Amount digested.....		98.9		1,360.4		26.7
	Per cent digested.....		51.9		95.0		48.4
	<i>Experiment No. 3.</i>						
37	Barley, cooked (water-free).....	1,101.6	120.5	13.1	953.6	42.7	14.4
80	Shoyu.....	171.0					28.9
121	Mustard.....	7.5	2.1	2.2	2.2	.9	.3
	Total.....	1,280.1	122.6	15.3	955.8	43.6	43.6
	Feces (water-free).....	157.3	63.0	25.6	52.9	17.2	15.8
	Amount digested.....		59.6		902.9	26.4	27.8
	Per cent digested.....		48.6		94.5	60.6	63.8
	<i>Experiment No. 4.</i>						
41	Rice, cooked (water-free).....	1,909.9	150.9	7.3	1,744.1		7.6
16	Beef extract.....	19.5	8.4		2.3		2.7
80	Shoyu.....	90.0					15.2
	Salt.....	2.2					2.2
	Total.....	2,021.6	159.3	7.3	1,746.4		27.7
	Feces (water-free).....	50.4	33.5	5.5	8.0		3.4
	Amount digested.....		125.8	1.8	1,738.4		24.3
	Per cent digested.....		79.0	24.7	99.5		87.7
	<i>Experiment No. 5.</i>						
41	Rice, cooked (water-free).....	1,897.4	150.0	7.2	1,732.6		7.6
16	Beef extract.....	4.1	1.9		.4		.6
80	Shoyu.....	18.0					3.1
	Salt.....	17.2					17.2
	Total.....	1,936.7	151.9	7.2	1,733.0		28.5
	Feces (water-free).....	43.5	28.6	4.0	8.6		2.3
	Amount digested.....		123.3	3.2	1,724.4		26.2
	Per cent digested.....		81.2	44.4	99.5		91.9

TABLE 65.—Results of digestion experiments Nos. 1-12—Continued.

Anal- ysis ref- er- ence No.	Kind of food.	Weight of ma- terial.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 6.</i>						
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
74	Beans, cooked (water-free).....	1,041.4	422.9	192.6	378.4	42.6	47.7
80	Shoyu.....	63.0					10.6
70	Sugar.....	170.0			160.9		.9
121	Mustard.....	2.8	.8	.8	.8	.3	.1
	Total.....	1,277.2	423.7	193.4	540.1	42.9	59.3
	Feces (water-free).....	420.3	161.9	126.2	100.3	32.2	31.9
	Amount digested.....		261.8	67.2	439.7	10.7	27.4
	Per cent digested.....		61.8	34.7	a 81.4	25.0	46.2
	<i>Experiment No. 7.</i>						
74	Beans, cooked (water-free).....	611.8	248.4	113.1	222.3	25.0	28.0
16	Beef extract.....	9.4	4.1		1.1		1.3
80	Shoyu.....	44.0					7.4
70	Sugar.....	182.0			b 171.2		.9
	Total.....	847.2	252.5	113.1	394.6	25.0	37.6
	Feces (water-free).....	204.6	78.0	70.3	40.0	15.8	16.3
	Amount digested.....		174.5	42.8	354.6	9.2	21.3
	Per cent digested.....		69.1	37.8	b 89.9	36.8	56.6
	<i>Experiment No. 8.</i>						
87	Tofu (water-free).....	763.4	459.5	182.0	89.2		32.7
80	Shoyu.....	100.0					16.9
67	Starch.....	50.0			41.7		
	Total.....	913.4	459.5	182.0	130.9		49.6
	Feces (water-free).....	51.7	18.0	4.8	15.2		13.7
	Amount digested.....		441.5	177.2	115.7		35.9
	Per cent digested.....		96.1	97.4	88.4		72.4
	<i>Experiment No. 9.</i>						
26	Porgy (water-free).....	773.9	705.4	14.9			46.0
80	Shoyu.....	57.0					9.6
	Salt.....	18.2					18.2
	Total.....	849.1	705.4	14.9			73.8
	Feces (water-free).....	30.3	16.3	4.0			6.5
	Amount digested.....		689.1	10.9			67.3
	Per cent digested.....		97.7	73.2			91.2
	<i>Experiment No. 10.</i>						
27	Salmon (water-free).....	1,066.3	879.2	115.6			48.1
80	Shoyu.....	22.0					3.7
	Salt.....	10.3					10.3
	Total.....	1,098.6	879.2	115.6			62.1
	Feces (water-free).....	34.0	17.3	7.2			5.5
	Amount digested.....		861.9	108.4			56.6
	Per cent digested.....		98.0	93.8			91.1

^a If it is assumed that the sugar was entirely digested, and it is therefore not included in the total carbohydrates of the diet, the coefficient of digestibility of carbohydrates of the beans would be 73.7 per cent.

^b If it is assumed that the sugar is entirely digested, and therefore it is not included in the total carbohydrates of the diet, the coefficient of digestibility of the carbohydrates of the beans would be 82.1 per cent.

TABLE 65.—Results of digestion experiments Nos. 1-12—Continued.

Anal- ysis ref- er- ence No.	Kind of food.	Weight of ma- terial.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 11.</i>						
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
21	Dried herring (water-free).....	793.8	716.2	42.8			13.3
80	Shoyu.....	175.0					26.2
71	Ame.....	300.0			^a 244.5		2.1
	Total.....	1,268.8	716.2	42.8			41.6
	Feces (water-free).....	77.0	50.6	8.5			7.8
	Amount digested.....		665.6	34.3			33.8
	Per cent digested.....		92.9	80.2			81.2
	<i>Experiment No. 12.</i>						
19	Dried codfish (water-free).....	736.2	701.5	3.4			16.1
71	Ame.....	250.0			^a 203.6		1.8
80	Shoyu.....	200.0					33.8
	Total.....	1,186.2	701.5	3.4			51.7
	Feces (water-free).....	50.0	32.9	4.8			7.3
	Amount digested.....		668.6				44.4
	Per cent digested.....		95.3				85.9

^a The carbohydrates consist largely of dextrin and maltose, and were assumed to be completely digested. See the description of ame on page 22.

DIGESTION EXPERIMENTS WITH MIXED DIET (Nos. 13-15).

These experiments formed part of an investigation, by Kellner and Mori^a, of diets which were believed to be common among three different classes in Japan. (See p. 67.) Each study continued six days, the same diet being used throughout the period. During the last three days urine and feces were collected and analyzed, and the digestibility of the diet determined. The analytical data regarding urine and feces were not reported. Such data for food materials used are included in Table 6.

The subject in each experiment was Y. M., a chemist, 23 years old, weighing 52 kilograms. In experiment No. 13 a mixed diet was used, the animal food consisting of beef. The diet in No. 14 was also a mixed diet, but the animal food was fish. In experiment No. 15 a vegetable diet was used, the principal item being a rice-barley mixture containing 2 parts of rice to 3 parts of barley.

The average daily amount of nitrogen in the urine for the three experiments was, respectively, 18.63, 14.37, and 9.84 grams. The quantity of urine eliminated was not reported.

^a Mitt. Deut. Gesell. Natur- u. Völkerk. Ostasiens, Tokyo, 4 (1887), No. 37, p. 305; Ztschr. Biol., 25 (1889), p. 102; Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), p. 148; Dai Nippon Shiritsu Eiseikwai Zasshi (Jour. Sanit. Soc. Japan), Tokyo, 1888, No. 55, p. 4.

TABLE 66.—Results of digestion experiments Nos. 13-15.

[Amounts of food and nutrients per day.]

Analysis reference No.	Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Nitrogen- free extract.	Crude fiber.	Ash.
<i>Experiment No. 13.</i>							
130	Beef, cooked, 250 grams; milk, 200 cubic centimeters; rice, cooked, 1,000 grams; vegetables, cooked, 200 grams; radish, pickled, 50 grams	Grams. 1,500	Grams. 123.0	Grams. 20.7	Grams. 409.7	Grams. 6.0	Grams. 20.6
	Feces.....	108	12.0		5.5	.5	3.1
	Amount digested.....		111.0		424.9	5.5	17.5
	Per cent digested.....		90.2		a 98.7	91.7	85.0
<i>Experiment No. 14.</i>							
129	Fish, cooked, 150 grams; rice, cooked, 1,200 grams; tofu, cooked, 150 grams; potatoes, cooked, 200 grams; radish, pickled, 100 grams	1,800	109.3	19.4	461.2	4.6	21.2
	Feces.....	98	13.9	4.0		8	3.5
	Amount digested.....		95.4		476.6	3.8	17.7
	Per cent digested.....		87.3		a 99.2	82.6	83.5
<i>Experiment No. 15.</i>							
128	Rice (2 parts), barley (3 parts), cooked, 1,200 grams; vegetables, cooked, 850 grams; radish, pickled, 100 grams	2,150	70.9	11.6	396.1	17.4	27.9
	Feces.....	231	17.2	11.9		4.2	5.0
	Amount digested.....		53.7		395.8	13.2	22.9
	Per cent digested.....		75.7		a 97.1	75.9	82.1

^a Assuming the digestibility of fat in mixed diet to be 85 per cent and in vegetable diet 82 per cent (see p. 206), the digestibility of total carbohydrates (including fiber) would be as follows: In experiment No. 13, 99.3 per cent; in No. 14, 99.6 per cent; and in No. 15, 96.6 per cent.

DIGESTION EXPERIMENTS WITH RICE AND TOFU (Nos. 16 and 17).

These experiments were made by T. Suchi,^a at the Physiological Institute of the University of Tokyo, in 1887. Their objects were, first, a study of the comparative digestibility of a rice and tofu diet with and without vegetable oil; and, second, the influence of oil upon protein metabolism in the body. The subject of the experiment was the observer himself, who was 21 years old and in good health.

The amount of fresh rice and of fresh tofu eaten per day was exactly the same in both experiments. In cooking the tofu 40 cubic centimeters of shoyu and 10 grams of sugar were used each day. In experiment No. 17 the tofu used was fried in rape-seed oil by the investigator himself, the amount of oil thus used being carefully weighed.

The quantity of water in the foods eaten was determined and used in computing the quantity of water-free material consumed. The composition of the water-free substance was assumed from the results of previous analyses of similar materials. The feces were

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), pp. 457, 511

analyzed. The urine was collected in 24-hour periods, the amount of urea in it determined by Liebig's method, and the nitrogen calculated from the urea. For the separation of the feces a pound of beef was eaten on the day preceding and the day following the experiment.

Digestion experiment No. 16.—This experiment continued seven days, November 18–24, 1887. The subject, T. S., weighed 41.30 kilograms at the beginning of the experiment and 41.51 kilograms at the end. The diet consisted of rice and tofu.

During this experiment the subject eliminated 7,140 cubic centimeters of urine, containing 175.29 grams of nitrogen.

Digestion experiment No. 17.—This experiment continued six days, November 29 to December 4, 1887, and was preceded by a preliminary period of three days during which the subject ate the same kinds and amounts of food with the exception of the oil. The subject, T. S., weighed 41.42 kilograms at the beginning of the experiment and 41.47 kilograms at the end. The diet during the experiment consisted of rice, tofu, and vegetable oil.

During this experiment the subject eliminated 5,225 cubic centimeters of urine, containing 143.1 grams of nitrogen.

TABLE 67.—Results of digestion experiments Nos. 16 and 17.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo- hydrates.	Ash.
	<i>Experiment No. 16.</i>					
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
42	Rice, cooked (water-free)	2,841.2	198.9	26.2	2,593.4	22.7
87	Tofu, cooked (water-free)	1,604.5	965.7	382.5	^a 187.6	68.7
	Total		1,164.6	408.7	2,781.0	91.4
	Feces (water-free)	137.5	55.7	14.1	46.9	20.8
	Amount digested		1,108.9	394.6	2,734.1	70.6
	Per cent digested		95.2	96.5	98.3	77.2
	<i>Experiment No. 17.</i>					
42	Rice, cooked (water-free)	2,435.3	170.5	22.5	2,222.9	19.4
87	Tofu, cooked (water-free)	1,375.2	827.7	327.8	^b 160.8	58.9
	Rape-seed oil	404.0		404.0		
	Total		998.2	754.3	2,383.7	78.3
	Feces (water-free)	135.7	57.6	45.8	15.8	16.5
	Amount digested		940.6	708.5	2,367.9	61.8
	Per cent digested		94.2	93.9	99.5	78.9

^a Includes 70 grams of sugar.

^b Includes 60 grams of sugar.

DIGESTION EXPERIMENT WITH RICE AND TOFU (No. 18).

This experiment was made by K. Osawa^a at the Physiological Institute of the University of Tokyo. The experimental methods were the same as those described for experiments Nos. 1–12. The percentage composition of the foods and feces was not reported. The

^a Chugai Iji Shimpo (Med. News, foreign and domestic), Tokyo, 1889, No. 211, p. 6.

experiment continued three days, June 20–22, 1887. The subject, J. M., was a medical student weighing 40.05 kilograms at the beginning and 40.08 kilograms at the end of the experiment. The diet consisted of rice and tofu, with small amounts of sugar, starch, and shoyu.

The amount of urine eliminated during the experiment was 2,400 cubic centimeters, containing 39.5 grams of nitrogen.

TABLE 68.—*Results of digestion experiment No. 18.*

Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo-hydrates.	Ash.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Rice, cooked (water-free).....	635.6	47.7	0.8	584.8	2.3
Tofu (water-free).....	348.1	203.1	91.7	33.5	19.8
Sugar (water-free).....	21.0			21.0	
Starch (water-free).....	60.8			60.8	
Shoyu (water-free).....	37.2				17.7
Total.....		250.8	92.5	700.1	39.8
Feces (water-free).....	88.0	12.0	4.8	8.6	6.6
Amount digested.....		238.8	87.7	691.5	33.2
Per cent digested.....		95.2	94.8	98.8	83.4

DIGESTION EXPERIMENT WITH MOCHI (No. 19).

This experiment was made by J. Tsuboi^a at the Hygienic Institute of Tokyo University. It began with breakfast, January 16, 1889, and continued two days. The subject, G. M., weighed 49 kilograms at the beginning and 49.55 kilograms at the end.

The diet consisted of mochi, a preparation from glutinous rice (see p. 21), which was roasted and eaten with shoyu. Analysis of the mochi is given in Table 6. Feces and urine were collected and analyzed, but the analytical data were not reported. For the separation of feces the yolks from 14 eggs were eaten at the second meal of the day preceding the experiment; and the third meal, or supper, was omitted. At noon of the day following the experiment, 234 grams of beef was taken. The first separation was unsatisfactory, as the feces from mochi was so similar in color to that from the egg yolks that it was found impossible to differentiate between them. The feces collected, therefore, pertained to both mochi and egg yolk. The digestibility of mochi as calculated by the investigator is shown in Table 69.

^aTokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 3 (1889), p. 1051.

TABLE 69.—*Results of digestion experiment No. 19.*

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo- hydrates.	Ash.
63a	Mochi.....	Grams. 3,305.0	Grams. 171.3	Grams. 7.2	Grams. 1,572.0	Grams. 7.1
	Shoyu.....	150.0				
	Feces (water-free).....	83.2	63.4	11.6	1.8	6.4
	Per cent digested (of mochi alone).....		64.2		99.9	82.2

The investigator stated that in calculating his results he made due allowance for the ingredients of the yolk and the shoyu, but did not explain the details of his calculations. From the data actually reported the compiler has also computed the coefficients of digestibility of the nutrients of mochi alone. These computations were made according to the assumption that the yolks from 14 eggs would weigh 255 grams, and that the digestibility of the nutrients in yolk and shoyu would be, protein 97 per cent, fat 95 per cent, and carbohydrates 98 per cent. The percentage composition of the yolk was assumed to be: Protein 15.7, fat 33.3, and ash 1.1 per cent; and for the shoyu, protein 8.5, carbohydrates 5.1, and ash 16.9 per cent.

By use of these data the amounts of nutrients in the yolk and shoyu eaten were calculated, and also the amounts of the corresponding ingredients in the feces that would pertain to these materials. The remaining ingredients of the feces were then assumed to be due to the mochi eaten. The results as thus computed are given in Table 70.

TABLE 70.—*Recalculated results of digestion experiment No. 19.*

Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo- hydrates.	Ash.
Food consumed:	Grams.	Grams.	Grams.	Grams.	Grams.
Mochi.....	3,305.0	171.3	7.2	1,572.0	7.1
Shoyu.....	150.0	12.7		7.6	25.3
Egg yolk.....	255.0	40.0	84.9		2.8
Total.....		224.0	92.1	1,579.6	35.2
Feces (water-free).....	83.2	63.4	11.6	1.8	6.4
Estimated feces from food other than mochi.....		1.6	4.2	.2	
Estimated feces from mochi.....		61.8	7.4	1.6	
Amount digested:					
From total food.....		160.6	80.5	1,577.8	28.8
From mochi alone.....		109.5		1,570.4	
Per cent digested:					
From total food.....		71.7	87.4	99.9	81.8
From mochi alone.....		63.9		99.9	

The results computed by the compiler agree very closely with those reported by the investigator.

The subject eliminated during the experiment 865 cubic centimeters of urine, containing 16.87 grams of nitrogen.

DIGESTION EXPERIMENT WITH RICE (No. 24).

This experiment was made by S. Nakasawa,^a at the Physiological Institute of the University of Tokyo, under the direction of Professor Osawa. It was the intention to study the comparative digestibility of rice and rice-barley diets, but in the course of the experiment with the rice-barley diet the subject suffered digestive disturbances and the experiment was discontinued; consequently only the results of the experiment with the rice diet are given. Both the food materials and the feces from this experiment were analyzed.

The experiment continued three days, February 14–16, 1890. The subject, S. N. (the observer himself), was a medical student 25 years old, weighing at the beginning of the experiment 46.28 kilograms and at the end 46.09 kilograms. For the separation of feces the subject ate 500 grams of meat at the noon meal of the day preceding the first day of the experiment, and the same at the first meal after the experiment.

During this experiment the subject eliminated 3,700 cubic centimeters of urine, containing 24.06 grams of nitrogen.

TABLE 71.—*Results of digestion experiment No. 24.*

Anal- ysis reference num- ber.	Kind of food.	Weight of material.	Protein (N×6.25)	Fat.	Carbo- hydrates.	Ash.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
46	Rice, cleaned.....	1,800.0	162.5	5.4	1,162.5	3.9
105	Nori.....	45.0	14.1	.7	17.5	4.1
111	Radish, pickled.....	330.0	14.8	.8	20.1	27.8
83	Shoyu.....	51.0	3.8		3.5	8.4
	Total.....	2,226.0	195.2	6.9	1,203.6	44.2
	Feces (water-free).....	68.7	37.6	7.6	16.3	7.2
	Amount digested.....		157.6		1,187.3	37.0
	Per cent digested.....		80.7		98.7	83.7

^a The figures given by the investigator for protein in rice do not agree with those computed by the compiler from the reported data, which are here given.

DIGESTION EXPERIMENTS WITH MIXED DIET (Nos. 25–27).

These experiments were made by J. Tsuboi and H. Murata,^b in 1887, as part of an investigation of the dietary of a students' dormitory at the University of Tokyo. The details of the dietary studies which were made in connection with the tests have already been given (pp. 77 to 80).

The experiments continued simultaneously for three days, beginning July 30, 1887. The subject in experiment No. 25 was a physician, 26 years old, weighing 40.15 kilograms. In experiment No. 26 the subject, an assistant at the Hygienic Institute, was 23 years old, and weighed 41.25 kilograms at the beginning and 39.75 kilo-

^a Chugai Iji Shimpō (Med. News, foreign and domestic), Tokyo, 1890, No. 251, p. 921.

^b Mitt. Med. Fakultät, Univ. Tokyo, 1 (1890), p. 359.

grams at the end. In experiment No. 27 the subject was a medical student, 26 years old, weighing 50.75 kilograms at the beginning and 51 kilograms at the end.

The diet was the same in kind for each subject, but varying amounts of the different materials were eaten. The weights of the different foods eaten at each meal were recorded, and samples were obtained for analysis. Some of the foods were analyzed, but the composition of others was assumed from the results of previous analyses of the same kinds of food. The figures for percentage composition were not reported.

For separation of the feces corresponding to the foods eaten during experiments, each subject consumed 700 cubic centimeters of milk on the day preceding and on the day following the experiment. Samples of the feces were analyzed, but the percentage composition of the feces was not given.

Urine was collected by each subject during the three days and the amounts of nitrogen and chlorin determined. The urine data were as follows for the total periods:

TABLE 72.—Amount and composition of urine in digestion experiments Nos. 25–27.

Whence obtained.	Total amount.	Nitrogen.	Sodium chlorid.
	<i>Cubic cm.</i>	<i>Grams.</i>	<i>Grams.</i>
Experiment No. 25	3,115	27.02	19.97
Experiment No. 26	1,750	23.30	17.97
Experiment No. 27	2,390	27.44	16.20

The results of the digestion experiments are here summarized:

TABLE 73.—Results of digestion experiments Nos. 25–27.

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
<i>Experiment No. 25.</i>					
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Beef, cooked	192.0	36.0	22.5	24.0	.....
Fish and eggs	238.0	21.3	20.4	23.4	.....
Rice, boiled	3,818.0	91.7	11.6	1,195.5	.....
Vermicelli	44.0	.8	.....	6.1	.....
Vegetables and pickles	1,475.0	10.6	2.6	72.1	.....
Total	5,767.0	160.4	57.1	1,321.1	53.4
Feces (water-free)	37.0	15.7	10.4	7.2	3.7
Amount digested		144.7	46.7	1,313.9	49.7
Per cent digested		90.2	81.8	99.5	93.1
<i>Experiment No. 26.</i>					
Beef, cooked	128.0	26.5	13.2	11.4	.....
Fish and eggs	211.0	19.4	17.4	20.8	.....
Rice, boiled	3,997.0	95.9	12.5	1,250.2	.....
Vermicelli	33.0	.6	.....	4.6	.....
Vegetables and pickles	1,303.0	10.0	2.6	71.1	.....
Total	5,672.0	152.4	45.7	1,358.1	47.9
Feces (water-free)	74.4	29.9	4.8	.....	(a)
Amount digested		122.5	40.9	.....	.....
Per cent digested		80.4	89.5	.....	.....

a Ash determination in the feces lost.

TABLE 73.—*Results of digestion experiments Nos. 25-27—Continued.*

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
<i>Experiment No. 27.</i>					
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Beef, cooked.....	195.0	35.7	23.5	25.5	.....
Fish and eggs.....	254.0	22.1	23.0	24.9	.....
Rice, boiled.....	4,372.0	105.0	17.1	1,362.8	.....
Vermicelli.....	41.0	7	.....	5.7	.....
Vegetables and pickles.....	1,389.0	10.0	2.5	66.7	.....
Total.....	6,251.0	173.5	66.1	1,485.6	54.3
Feces (water-free).....	86.5	27.2	5.3	47.6	6.4
Amount digested.....	.....	146.3	60.8	1,438.0	47.9
Per cent digested.....	.....	84.3	92.0	96.8	88.2

DIGESTION EXPERIMENTS WITH RICE, RICE-BARLEY, AND BREAD RATIONS
(Nos. 51-69).

These experiments were made by Mori, Oi, and Iishima,^a at the Army Medical College, Tokyo, in 1889, as part of an investigation (see p. 84) of the relative merits of the three different rations in use in the army, namely, the rice ration, the rice-barley ration, and the European or bread ration. In the first of these the principal item of the diet was rice, which was supplemented by beef, fish, eggs, and vegetables. The rice-barley ration was similar, except that barley was substituted for part of the rice. The bread ration consisted chiefly of bread, meat, and vegetables, though rice was substituted for bread at one meal every third day.

In addition to these, one experiment (No. 63) was made with a ration the same as the rice-barley ration, except that barley was substituted entirely for the rice-barley mixture. Such a ration, with barley as the only cereal, has never been used in the army.

The subject in experiment No. 63 was a military nurse. In all the other experiments infantry soldiers were subjects. Six individual tests were made with each regular ration, the soldiers in each case being selected from battalions in which the particular ration was used, so that there should be no change in diet at the time of the experiment. The subjects were not restricted in amount of food, but each ate such quantities as he desired. Their physical exercises were continued during the experiment the same as usual; in fact, an effort was made to have all the conditions perfectly normal.

The quantities of food eaten at each meal were determined, and samples were obtained for analysis. Feces were separated each day

^a Gun-i Gakko Gyofu (Arb. K. Japan. Militär-Ärzt. Lehranst.) [Bul. Army Med. Col., Tokyo, 1892, No. 1, pp. 1, 35, 60.

by the use of raw beans, and the proportions of water, nitrogen, and ash determined. Nitrogen was determined by the Gunning method, and in the food samples fat was determined by extracting with ether in a Soxhlet apparatus. Fat in feces was not determined, as the investigators believed that in the case of feces simple extraction with ether did not give very satisfactory results, and that, furthermore, the quantity of fat in the diet was so small that it had little significance in the investigations. The data regarding the percentage composition of food and feces were not reported.

In the original report the digestibility of the nutrients in the food was calculated for each day and was averaged for the whole period. Since the quantities of feces for the different days were very irregular, it would seem preferable to compute the digestibility according to the data for the whole period of a given study rather than for the separate days, and the results as given in the present compilation have been thus recalculated from the data given in the original report. In a few cases slight discrepancies were found between the average coefficients of digestibility as given in the original report and those calculated by the compiler. So far as possible the original figures have been retained; wherever the compiler's figures are used they are indicated by parentheses.

As stated above, the investigators did not determine the quantity of fat in feces. In calculating the digestibility of carbohydrates they considered the difference between 100 and the sum of the quantities of water, protein ($N \times 6.25$), and ash in feces as the measure of the amount of carbohydrates in feces. Such difference represents nitrogen-free organic material, including both fat and carbohydrates; hence this method of calculation is not strictly accurate; but inasmuch as the amount of fat in the diets studied was so small, usually less than 20 grams a day, and had a correspondingly small significance in the results of the studies, the results as thus computed by the investigator have been retained here. Doubtless the small amount of fat in the diet was quite thoroughly digested, so that any error thus introduced must be inappreciable.

Every experiment continued eight days. Nos. 51-56, with the army rice ration, began with breakfast August 12, 1889; Nos. 57-62, with the rice-barley ration, began October 15, 1889, and at the same time No. 63, with the barley ration, was also conducted; Nos. 64-69, with the European or bread ration, began December 13, 1889.

Urine was collected each day, and the proportions of nitrogen, phosphoric acid, and sodium chlorid were determined. Phosphoric acid was determined by titrating with uranium acetate and chlorin by Mohr's method. The average daily quantity of urine, and of nitrogen, phosphoric acid, and sodium chlorid in the urine, for each subject, was as follows:

TABLE 74.—Average daily elimination of urine, and of nitrogen, phosphoric acid, and sodium chlorid in the urine, in digestion experiments Nos. 51–69.

Whence obtained.	Weight of subject.	Quantity of urine.	Nitrogen.	Phosphoric acid.	Sodium chlorid.
	<i>Kilos.</i>	<i>Cubic c.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Experiment No. 51	54.65	1,172	9.17	1.38	18.84
Experiment No. 52	55.22	1,341	8.53	1.19	16.65
Experiment No. 53	66.71	974	10.42	1.88	20.87
Experiment No. 54	59.65	1,244	9.22	1.85	21.16
Experiment No. 55	56.81	890	9.16	1.82	14.40
Experiment No. 56	56.30	784	8.05	1.37	11.59
Experiment No. 57	56.50	1,594	8.99	1.48	20.66
Experiment No. 58	61.00	1,735	10.89	2.07	25.81
Experiment No. 59	61.70	1,608	9.66	1.71	22.01
Experiment No. 60	57.45	1,388	9.50	1.59	23.56
Experiment No. 61	59.50	1,569	12.92	2.09	24.30
Experiment No. 62	56.70	1,750	9.97	1.78	24.33
Experiment No. 63	52.20	2,227	9.70	1.73	24.78
Experiment No. 64	57.75	1,234	13.23	2.18	19.03
Experiment No. 65	61.65	997	12.27	1.72	19.79
Experiment No. 66	60.85	1,405	13.78	2.13	19.51
Experiment No. 67	58.00	1,335	13.21	2.04	18.95
Experiment No. 68	60.15	1,232	14.34	2.36	19.22
Experiment No. 69	54.60	1,044	12.42	1.70	18.13

The results of the digestion experiments follow:

TABLE 75.—Results of digestion experiments Nos. 51–69.

Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo-hydrates.	Ash.
<i>Experiment No. 51.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Rice, cooked	11,823	401.1	24.9	3,398.0	43.1
Soup	2,020	35.7	6.5	43.3	14.3
Meats, fish, and vegetables (supplemental food)	4,285	267.4	86.5	567.1	166.0
Total		704.2	117.9	4,008.4	223.4
Feces	764	108.6		76.6	27.0
Amount digested		595.6		3,931.8	196.4
Per cent digested		85.3		98.1	(87.9)
<i>Experiment No. 52.</i>					
Rice, cooked	11,397	387.4	24.0	3,812.9	41.6
Soup	2,055	41.7	7.6	47.6	15.5
Meats, fish, and vegetables (supplemental food)	4,332	270.0	89.2	533.3	178.2
Total		699.1	120.8	4,393.8	235.3
Feces	1,244	98.6		51.1	23.0
Amount digested		600.5		4,342.7	212.3
Per cent digested		85.5		98.3	(90.3)
<i>Experiment No. 53.</i>					
Rice, cooked	11,706	397.3	24.6	3,916.7	42.7
Soup	2,185	45.5	7.4	53.5	16.9
Meats, fish, and vegetables (supplemental food)	4,542	275.4	94.9	594.4	181.5
Total		718.2	126.9	4,594.6	241.1
Feces	834	115.7		56.1	27.7
Amount digested		602.5		4,538.5	213.4
Per cent digested		84.4		98.8	(88.5)
<i>Experiment No. 54.</i>					
Rice, cooked	11,426	387.6	24.0	3,823.5	41.7
Soup	2,055	41.7	7.7	47.6	15.5
Meats, fish, and vegetables (supplemental food)	4,435	264.5	89.3	550.6	175.2
Total		693.8	121.0	4,421.7	232.4
Feces	1,393	128.4		79.7	30.5
Amount digested		565.4		4,342.0	201.9
Per cent digested		81.4		98.2	(86.9)

TABLE 75.—Results of digestion experiments Nos. 51-69—Continued.

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 55.</i>					
Rice, cooked.....	11,594	393.4	24.4	3,878.5	42.3
Soup.....	2,235	41.7	7.7	59.0	15.5
Meats, fish, and vegetables (supplemental food).....	3,789	238.7	81.8	506.1	147.2
Total.....		673.8	113.9	4,443.6	205.0
Feces.....	694	115.2		42.2	21.6
Amount digested.....		558.6		4,401.4	183.4
Per cent digested.....		82.9		99.0	(89.5)
<i>Experiment No. 56.</i>					
Rice, cooked.....	9,826	333.4	20.7	3,287.9	35.9
Soup.....	1,695	33.6	7.1	35.5	12.6
Meats, fish, and vegetables (supplemental food).....	3,417	223.7	81.2	468.4	133.9
Total.....		590.7	109.0	3,791.8	183.4
Feces.....	960	98.0		54.6	19.0
Amount digested.....		492.7		3,737.2	164.4
Per cent digested.....		(83.4)		(98.6)	(89.7)
<i>Experiment No. 57.</i>					
Rice-barley, cooked.....	11,719	284.7	8.8	3,120.4	39.3
Rice dumpling.....	995	24.4	.7	262.2	3.4
Soup.....	3,520	106.9	35.0	108.3	61.5
Meats, fish, and vegetables (supplemental food).....	3,371	175.6	47.0	247.3	125.3
Total.....		591.6	91.5	3,738.2	229.5
Feces.....	1,176	162.6		120.6	43.5
Amount digested.....		429.0		3,617.6	186.0
Per cent digested.....		72.7		96.8	(81.0)
<i>Experiment No. 58.</i>					
Rice-barley, cooked.....	12,359	302.6	8.5	3,255.8	42.0
Rice dumpling.....	630	20.0	1.4	201.6	1.5
Soup.....	3,685	107.2	35.1	114.4	64.4
Meats, fish, and vegetables (supplemental food).....	4,137	208.6	61.1	306.3	160.6
Total.....		638.4	106.1	3,878.1	268.5
Feces.....	1,293	167.2		136.3	46.3
Amount digested.....		471.2		3,741.8	222.2
Per cent digested.....		73.7		96.5	(82.8)
<i>Experiment No. 59.</i>					
Rice-barley, cooked.....	12,153	297.6	8.3	3,205.1	41.3
Rice dumpling.....	570	18.0	1.3	181.4	1.3
Soup.....	3,885	112.4	37.1	118.6	68.6
Meats, fish, and vegetables (supplemental food).....	4,014	203.4	59.1	287.3	155.2
Total.....		631.4	105.8	3,792.4	266.4
Feces.....	1,650	161.6		133.3	42.6
Amount digested.....		469.8		3,659.1	223.8
Per cent digested.....		(74.4)		96.5	(84.0)
<i>Experiment No. 60.</i>					
Rice-barley, cooked.....	12,158	297.7	8.3	3,222.9	41.3
Rice dumpling.....	595	18.9	1.3	190.4	1.4
Soup.....	3,695	107.2	35.1	120.3	64.5
Meats, fish, and vegetables (supplemental food).....	3,924	200.3	58.0	290.8	151.5
Total.....		624.1	102.7	3,824.4	258.7
Feces.....	1,718	242.1		130.6	47.0
Amount digested.....		382.0		3,693.8	211.7
Per cent digested.....		(61.2)		96.6	(81.9)

TABLE 75.—Results of digestion experiments Nos. 51–69—Continued.

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
<i>Experiment No. 61.</i>					
Rice-barley, cooked.....	12,005	293.9	8.2	3,174.5	40.8
Rice dumpling.....	560	17.8	1.2	179.2	1.3
Soup.....	4,070	117.1	39.0	115.4	72.3
Meats, fish, and vegetables (supplemental food).....	3,931	197.3	55.7	291.1	150.2
Total.....		626.1	104.1	3,761.2	264.6
Feces.....	1,395	156.2		124.6	45.9
Amount digested.....		469.9		3,636.6	218.7
Per cent digested.....		(75.0)		96.4	(82.6)
<i>Experiment No. 62.</i>					
Rice-barley, cooked.....	12,337	301.9	8.4	3,241.3	41.9
Rice dumpling.....	555	17.6	1.2	177.6	1.3
Soup.....	4,105	123.1	39.8	131.8	73.9
Meats, fish, and vegetables (supplemental food).....	3,940	196.6	57.9	291.5	151.9
Total.....		639.2	107.3	3,842.2	269.0
Feces.....	1,593	209.5		138.1	51.0
Amount digested.....		429.7		3,704.1	218.0
Per cent digested.....		(67.2)		96.8	(81.1)
<i>Experiment No. 63.</i>					
Barley, cooked.....	12,654	240.6	8.9	1,955.4	22.1
Soup.....	3,315	101.6	32.7	99.5	59.5
Meats, fish, and vegetables (supplemental food).....	4,097	204.4	59.1	292.6	158.0
Total.....		546.6	100.7	2,347.5	239.6
Feces.....	3,491	212.1		281.2	65.8
Amount digested.....		334.5		2,066.3	173.8
Per cent digested.....		(61.2)		87.9	(72.5)
<i>Experiment No. 64.</i>					
Bread.....	4,368	202.0	2.4	2,464.1	29.8
Rice, cooked.....	1,572	52.2	.7	507.3	5.5
Soup.....	4,717	91.5	26.3	152.6	62.8
Meats, fish, and vegetables (supplemental food).....	4,121	293.9	151.7	422.4	95.7
Total.....		639.6	181.1	3,546.4	193.8
Feces.....	2,265	136.2		138.5	39.9
Amount digested.....		503.4		3,407.9	153.9
Per cent digested.....		78.7		96.3	(79.4)
<i>Experiment No. 65.</i>					
Bread.....	4,345	200.9	2.4	2,456.3	29.0
Rice, cooked.....	1,410	46.7	.6	455.2	4.9
Soup.....	4,992	96.7	27.8	165.2	67.4
Meats, fish, and vegetables (supplemental food).....	4,055	290.5	132.3	471.2	93.2
Total.....		634.8	163.1	3,547.9	194.5
Feces.....	1,751	133.4		112.7	37.9
Amount digested.....		501.4		3,435.2	156.6
Per cent digested.....		78.4		96.9	(80.5)
<i>Experiment No. 66.</i>					
Bread.....	4,417	204.4	2.4	2,484.4	29.4
Rice, cooked.....	1,456	48.2	.7	471.1	5.1
Soup.....	4,717	91.4	26.2	152.6	63.5
Meats, fish, and vegetables (supplemental food).....	3,972	282.8	143.9	449.5	91.3
Total.....		626.8	173.2	3,557.6	189.3
Feces.....	1,457	111.3		103.2	32.5
Amount digested.....		515.5		3,454.4	156.8
Per cent digested.....		82.1		97.1	(82.8)
<i>Experiment No. 67.</i>					
Bread.....	4,323	200.0	2.4	2,439.3	28.7
Rice, cooked.....	1,460	48.3	.7	471.3	5.1
Soup.....	4,708	90.3	25.9	146.5	62.4
Meats, fish, and vegetables (supplemental food).....	4,104	290.8	141.0	429.5	92.5
Total.....		629.4	170.0	3,486.6	188.7
Feces.....	1,674	111.9		114.9	36.6
Amount digested.....		517.5		3,371.7	152.1
Per cent digested.....		(82.2)		97.4	(80.6)

TABLE 75.—Results of digestion experiments Nos. 51-69—Continued.

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 68.</i>					
Bread.....	Grams. 4,424	Grams. 204.5	Grams. 2.6	Grams. 2,496.4	Grams. 29.5
Rice, cooked.....	1,453	46.8	.5	470.3	5.1
Soup.....	4,731	90.8	26.0	143.4	63.1
Meats, fish, and vegetables (supplemental food).....	3,966	285.6	143.7	429.7	86.0
Total.....		627.7	172.8	3,539.8	183.7
Feces.....	1,945	104.2		116.0	37.1
Amount digested.....		523.5		3,423.8	146.6
Per cent digested.....		83.0		(96.7)	(79.8)
<i>Experiment No. 69.</i>					
Bread.....	4,476	206.9	2.5	2,514.5	30.5
Rice, cooked.....	1,487	49.4	.7	467.8	5.2
Soup.....	3,916	75.9	21.7	122.6	51.4
Meats, fish, and vegetables (supplemental food).....	4,033	287.1	144.5	415.8	92.5
Total.....		619.3	169.4	3,520.7	179.6
Feces.....	1,768	111.0		125.5	37.1
Amount digested.....		508.3		3,395.2	142.5
Per cent digested.....		(82.1)		96.4	(79.3)

DIGESTION EXPERIMENTS WITH MIXED DIET (Nos. 70 and 71).

These two experiments were made by G. Oi^a as part of an investigation (see p. 89) of the army rice and bread rations. The rice ration consisted principally of rice and fish, with some vegetables, and the bread ration consisted mainly of bread and meat, but also included some vegetables. The date of the investigation was not stated.

Each experiment continued twelve days. The subjects were ten military nurses, whose ages and weights were not given. The amounts of food eaten were not limited, but each subject ate as much as he desired of the diet studied. Samples of the food, feces, and urine were analyzed, but the data regarding the analyses were not reported. The results of the experiments as given in the original report show the average amounts per man per day, and the data are given in the same manner in Table 76.

The fat in the feces was not determined, nitrogen-free extract including fat being designated as carbohydrates and used as such in computing the digestibility of the carbohydrates. The error thus introduced, however, is proportionally small, since the total amount of fat in the diet was limited and was probably quite thoroughly digested.

The average daily amount of urine eliminated per subject in experiment No. 70 was 1,171 grams, containing 12.75 grams of

^aGun-i Gakko Gyofu (Arb. K. Japan. Militär-Ärztl. Lehranst.) [Bul. Army Med. Col.], Tokyo, 1892, No. 1, p. 111.

nitrogen, and in experiment No. 71 it was 1,260 grams, containing 16.58 grams of nitrogen.

TABLE 76.—*Results of digestion experiments Nos. 70 and 71.*

[Amounts of food and nutrients per man per day.]

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
<i>Experiment No. 70.</i>					
Rice, fish, and vegetables.....	<i>Grams.</i> 2,535.0	<i>Grams.</i> 84.69	<i>Grams.</i> 20.05	<i>Grams.</i> 625.99	<i>Grams.</i> 22.84
Total.....	2,535.0	84.69	20.05	625.99	22.84
Feces.....	106.0	2.25	19.86		3.00
Amount digested.....		82.44	626.18		19.84
Per cent digested.....		97.3	(96.9)		(86.9)
<i>Experiment No. 71.</i>					
Bread, meat, and vegetables.....	1,942.6	112.95	55.09	460.06	29.87
Total.....	1,942.6	112.95	55.09	460.06	29.87
Feces.....	122.0	2.87	18.19		2.66
Amount digested.....		110.08	496.96		27.21
Per cent digested.....		97.4	(96.5)		(91.1)

DIGESTION EXPERIMENTS WITH MILK AND "HEALTH" (Nos. 72 and 73).

These experiments were made by "Kumagawa and Kaneda," at the Physiological Institute of the University of Tokyo. The object was to study the comparative digestibility of milk and of "Health," a commercial article prepared from tortoise flesh, which was claimed to be an excellent substitute for milk.

Experiment No. 72 began February 28, 1893 (?), and continued eight days, and No. 73 began March 8, 1893 (?), and continued six days. The subject in every case was G. K., a laboratory assistant.

In both tests the special food material was eaten with rice and pickles, the amounts used being exactly the same each day in both experiments. The amount of "Health" used was regulated by a comparison of the composition of "Health" with that of milk, the smaller amount of fat in the former being counterbalanced by adding an isodynamic amount of sugar.

All the food materials and feces were analyzed, the results of analyses being included in Tables 6 and 64. Powdered charcoal was used for separating the feces. Urine was collected each day from 7.30 a. m. one day until the same hour the following day, but no data regarding the amount or the composition of the urine were reported.

The digestibility of carbohydrates in both cases was identical and extremely high. The digestibility of protein and of fat was larger in the diet with milk than in that with "Health." The authors believed

^aOkayama Igakukwai Zasshi (Jour. Okayama Med. Soc.), 1893, No. 41, p. 179.

that the differences were sufficient to indicate that these nutrients in "Health" were not so thoroughly digested as in milk, considering that the amount of other foods used in both experiments was exactly the same.

TABLE 77.—Results of digestion experiments Nos. 72 and 73.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 72.</i>						
47	Rice, cleaned.....	Grams. 4,000.0	Grams. 282.1	Grams. 15.0	Grams. 2,991.4	Grams. 7.8
36	Milk.....	4,000.0	126.0	157.7	148.1	31.3
123	Pickles.....	400.0	29.9	3.0	43.2	73.9
	Total.....		438.0	175.7	3,182.7	113.0
	Feces (water-free).....	107.8	63.3	13.1	15.7	15.7
	Amount digested.....		374.7	162.6	3,167.0	97.3
	Per cent digested.....		85.5	92.6	99.5	86.1
<i>Experiment No. 73.</i>						
47	Rice, cleaned.....	3,000.0	211.5	11.3	2,243.5	5.9
33	"Health".....	342.0	94.4	38.0	178.7	12.4
123	Pickles.....	300.0	22.5	2.2	32.4	55.4
	Sugar.....	120.0			120.0	
	Total.....		328.4	51.5	2,574.6	73.7
	Feces (water-free).....	97.3	64.8	9.2	13.2	10.1
	Amount digested.....		263.6	42.3	2,561.4	63.6
	Per cent digested.....		80.3	82.1	99.5	86.3

DIGESTION EXPERIMENT WITH FROZEN MOCHI (No. 74).

This experiment, which was reported by R. Mori,^a was made by an army surgeon, T. Saka, to determine the digestibility and nutritive value of Kohori mochi, and to test the practicability of its use as an emergency food in the army. The Kohori mochi, or frozen mochi (for description of mochi see p. 21), is a preparation that is commonly used in the northern provinces of Japan, which is made by soaking mochi in water for four to five days in severely cold weather, and then drying it in the air. The material thus prepared will keep well for a long time.

The experiment began April 13, 1894, and continued five days, the only food eaten being the frozen mochi. The subject was the investigator himself. During the experiment he attended his daily duties as an army surgeon, which necessitated considerable horseback riding. He felt well during the experiment, did not dislike the food, and had a good appetite throughout the whole period. He used 10 to 20 grams of raw red mungo bean for the separation of the feces, which proved very effectual.

^a Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 8 (1894), p. 503.

The place at which the experiment was made was not mentioned, and no data were reported regarding the age or weight of the subject, or the analyses of food and feces.

TABLE 78.—Results of digestion experiment No. 74.

Analysis reference No.	Kind of food.	Weight of material.	Protein (N×5.25).	Fat.	Carbo-hydrates.	Ash.
		Grams.	Grams.	Grams.	Grams.	Grams.
64	Frozen mochi.....	2,761.0	493.5	35.9	1,716.7	26.2
	Total.....	2,761.0	493.5	35.9	1,716.7	26.2
	Feces (water-free).....	87.5	67.0	8.6	3.9	8.0
	Amount digested.....		426.5	27.3	1,712.8	18.2
	Per cent digested.....		86.4	76.1	99.8	69.5

DIGESTION EXPERIMENT WITH BUCKWHEAT FLOUR (No. 75).

This experiment was made by Y. Washitsu and K. Uki^a in the Army Medical College at Tokyo, the object being to determine the digestibility of buckwheat flour. The flour was mixed thoroughly with boiling water and eaten with the addition of a little salt and meat extract. The quantity of salt used was not stated. Raw red mungo bean was used for the separation of the feces.

The experiment began December 26, 1894, and continued three days. The subject, K. Y., was a laboratory servant, 47 years old, weighing 45.78 kilograms at the beginning of the experiment and 45.15 kilograms at the end.

The nitrogen in the meat extract was not considered by the investigator in calculating the coefficient of digestibility of the flour. The digestibility of the nitrogenous bodies in the extract, which are largely in the form of nonproteid, would be high, probably 99 per cent, and the omission of the nitrogen of the meat extract would therefore affect the coefficients of digestibility of the protein of the flour but very little.

TABLE 79.—Results of digestion experiment No. 75.

Analysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
		Grams.	Grams.	Grams.	Grams.	Grams.
40	Buckwheat.....	1,800.0	146.3	22.0	1,398.4	29.1
	Meat extract.....	15.7				
	Total.....		146.3	22.0	1,398.4	29.1
	Feces (water-free).....	140.0	37.6	20.7	44.2	24.6
	Amount digested.....		108.7	1.3	1,354.2	
	Per cent digested.....		74.3	5.9	96.8	

^a Gun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1896, No. 2, p. 50.

DIGESTION EXPERIMENTS WITH WHEAT AND BUCKWHEAT PREPARATIONS (Nos. 76-80).

These experiments were made by K. Kawanishi,^a at the Hygienic Laboratory of the Army Medical College, Tokyo, for the purpose of determining the digestibility of some cereal food materials in common use in Japan. One experiment was made with a buckwheat preparation, "sobakiri" (see p. 21), and two each with macaroni and vermicelli. The subject in all the experiments was a laboratory servant, K. Y., 49 years old, weighing 47 kilograms.

Each experiment continued three days, the date of the beginning of each being as follows: No. 76, November 26, 1895; No. 77, January 10, 1896; No. 78, February 26, 1896; No. 79, February 23, 1896; and No. 80, March 6, 1896.

In each case the diet consisted simply of the cereal food material under investigation, with some beef extract and shoyu. The nitrogenous materials in beef extract and in shoyu were ignored in calculating the coefficient of digestibility of the protein of the ration. In both these food adjuncts the nitrogenous bodies are largely non-proteid, and their digestibility would probably be so high that the exclusion of them from the calculations would affect the coefficients of digestibility of the protein of the ration but very little.

Samples of the foods and feces were analyzed in the usual manner, and the results of analyses were reported and are included in Tables 6 and 64. For the separation of feces, raw red mungo beans were used as a marker except in experiment No. 79, in which case black sesame seed was employed.

TABLE 80.—Results of digestion experiments Nos. 76-80.

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein. (N×6.25).	Fat.	Carbo- hydrates.	Ash.
	<i>Experiment No. 76.</i>					
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	
58	Buckwheat preparation, "sobakiri"	1,889.0	146.43	22.79	1,523.74	27.54
17	Beef extract	66.0	^b 5.30	.....	.....	.....
84	Shoyu	217.0	^b 12.20	.....	.....	.....
	Total		146.43	22.79	1,523.74	27.54
	Feces ^c	106.0	34.04	5.37	42.61	16.19
	Amount digested		111.79	17.42	1,481.13	11.35
	Per cent digested		76.3	76.4	97.2	41.2
	<i>Experiment No. 77.</i>					
61	Macaroni ^c	1,782.0	187.11	10.39	1,476.01	17.16
17	Beef extract	56.0	^b 4.50	.....	.....	.....
85	Shoyu	167.0	^b 7.44	.....	.....	.....
	Total		187.11	10.39	1,476.01	17.16
	Feces ^c	28.7	10.64	1.44	11.61	3.43
	Amount digested		176.47	8.95	1,465.40	13.73
	Per cent digested		94.3	86.1	99.2	80.0

^a Gun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1896, No. 2, p. 53.

^b Not included in total.

^c The weight is that of partially dried material.

TABLE 80.—Results of digestion experiments Nos. 76–80—Continued.

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein (N × 6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 78.</i>						
62	Macaroni ^a	Grams. 1,458.0	Grams. 176.87	Grams. 7.58	Grams. 1,176.96	Grams. 9.10
17	Beef extract.....	59.0	^b 4.74			
85	Shoyu.....	361.0	^b 16.08			
	Total.....		176.87	7.58	1,176.96	9.10
	Feces ^a	27.0	12.06	1.39	8.71	4.10
	Amount digested.....		164.82	6.19	1,168.25	5.00
	Per cent digested.....		93.2	82.3	99.3	55.0
<i>Experiment No. 79.</i>						
65	Vermicelli ^a	1,208.0	146.87	7.01	928.49	19.33
17	Beef extract.....	58.0	^b 5.66			
85	Shoyu.....	323.0	^b 14.39			
	Total.....		146.87	7.01	928.49	19.33
	Feces ^a	40.0	16.13	1.80	12.45	5.55
	Amount digested.....		130.74	5.21	916.04	13.78
	Per cent digested.....		89.0	75.6	98.7	71.3
<i>Experiment No. 80.</i>						
66	Vermicelli ^a	1,192.0	123.86	9.06	953.27	19.39
17	Beef extract.....	56.0	^b 4.50			
85	Shoyu.....	382.0	^b 17.01			
	Total.....		123.86	9.06	953.27	19.39
	Feces ^a	39.0	16.12	1.85	13.49	6.36
	Amount digested.....		107.74	7.21	939.78	13.03
	Per cent digested.....		87.0	79.6	98.6	67.2

^a The weight is that of partially dried material.^b Not included in total.

DIGESTION EXPERIMENTS WITH SINGLE FOOD MATERIALS (Nos. 81–98).

These experiments were made by S. Kano and S. Iishima,^a at the Army Medical College, Tokyo. The diet consisted of the special food material under experiment, though in every case but one shoyu was used with it to increase the flavor. Each experiment continued only one day, as experience had shown the investigators that with a diet consisting of a single food material, especially in the case of vegetables, a longer period was likely to cause disturbances of the digestive functions, resulting in diarrhea.

For the separation of the feces several different agents were tried as markers. Milk was found to be unsatisfactory because it has a tendency to produce diarrhea. Whole buckwheat flour containing the black husk, combined with red mungo beans, raisins, or black sesame seed, was used with more or less satisfactory results. The outer skin of red pepper proved to be very satisfactory in some instances. For this purpose the red skin was soaked in water to extract the irritating principle, then cut into small pieces and eaten with whole buckwheat flour.

^a Gun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1899, No. 3, p. 101.

The results of analyses of food materials used in these experiments are given in Table 6, indicated by analysis reference numbers; those of feces are given in Table 64, and designated by the same numbers as the experiments themselves.

In calculating the coefficients of digestibility of protein, the nitrogenous material of shoyu was not taken into account. The digestibility of the carbohydrates was not calculated in the original report, but in each experiment has been computed by the compiler from the data given in the original report. Such coefficients are inclosed in parentheses.

Experiment No. 81.—This experiment was made October 5, 1897. The subject was K. Y., a laboratory servant. The diet consisted of pumpkin. The separation of the feces was made satisfactorily by use of whole buckwheat flour.

Experiment No. 82.—This experiment was made October 12, 1897. The subject was S. K., one of the investigators. The diet consisted of taro. A satisfactory separation of the feces was obtained by the use of whole buckwheat flour.

Experiment No. 83.—This experiment was made October 19, 1897. The subject was S. I., one of the investigators. The diet consisted of yam (*Dioscorea*). The separation of the feces was accomplished by use of buckwheat and dried grapes.

Experiment No. 84.—This experiment was made December 8, 1897. The subject was K. Y., a laboratory servant. The diet consisted of a tuberous vegetable, stachys (*Stachys sieboldi*). For the separation of the feces whole buckwheat flour and red pepper skin previously soaked in water were used with very good results.

Experiment No. 85.—This experiment was made November 11, 1897. The subject was K. Y., a laboratory servant. The diet consisted of potatoes. The separation of the feces was accomplished by means of whole buckwheat flour and red pepper skin.

Experiment No. 86.—This experiment was made November 15, 1897. The subject was M., an army surgeon. The diet consisted of lily bulb. Buckwheat and red pepper skin were used for separation of the feces with good results.

Experiment No. 87.—This experiment was made November 5, 1897. The subject was K. Y., a laboratory servant. The diet consisted of arrowhead root. Buckwheat flour and red pepper skin were used for separation of the feces.

Experiment No. 88.—This experiment was made November 18, 1897. The subject was N., an army surgeon. The diet consisted of lotus rhizome. Buckwheat and red pepper skin were used for separation of the feces.

Experiment No. 89.—This experiment was made October 23, 1897. The subject was K. Y., a laboratory servant. The food consisted of

fu (kingyo), a gluten preparation (see p. 20). For separation of the feces buckwheat and raw red adzuki beans were used.

Experiment No. 90.—This experiment was made December 11, 1897. The subject was K. Y., a laboratory servant. The food consisted of fu (kiri), a gluten preparation (see p. 20). For separation of the feces buckwheat and red pepper skin were used. In the opinion of the investigators the separation of the feces appeared to be good, but it is possible that a portion of the feces pertained to food other than the gluten preparation of the experiment, which would account for the fact that the quantity of fiber in the feces was larger than that in the food.

Experiment No. 91.—This experiment was made November 14, 1897. The subject was K. Y., a laboratory servant. The diet consisted of dry bread (biscuit or cracker). It was not described, but was probably pilot bread or something similar. Buckwheat and red pepper were used for the separation of the feces.

Experiment No. 92.—This experiment was made October 7, 1897. The subject was N., an army surgeon. The diet consisted of tofu. Buckwheat was used for the separation of the feces.

Experiment No. 93.—This experiment was made October 12, 1897. The subject was M., an army surgeon. The diet consisted of tofu cake, or kara, the soy-bean residue remaining from the preparation of tofu (see p. 26). Buckwheat was used for the separation of the feces.

Experiment No. 94.—This experiment was made October 6, 1897. The subject was S. I., one of the investigators. The diet consisted of yuba, which is the coagulated legumin of soy bean (see p. 27). For the separation of the feces buckwheat and dried grapes were used.

Experiment No. 95.—This experiment was made November 11, 1897. The subject was M., an army surgeon. The diet consisted of konnyaku (see p. 35). For the separation of the feces buckwheat and red pepper were used.

Experiment No. 96.—This experiment was made December 1, 1897. The subject was S. K., one of the investigators. The diet consisted of katakuri starch made from *Erythronium dens-canis*. For the separation of the feces whole buckwheat flour was used.

Experiment No. 97.—This experiment was made December 9, 1897. The subject was S. I., one of the investigators. The diet consisted of kazu starch made from *Pueraria thunbergiana*. For the separation of the feces buckwheat and pickled radish were used before the experiment, and buckwheat and cooked lotus rhizome after the experiment. The separation was satisfactory. Buckwheat alone failed to give good results.

Experiment No. 98.—This experiment was made October 19, 1897. The subject was K. Y., a laboratory servant. The diet consisted of

dried gourd "kampyo." For the separation of the feces buckwheat flour was used.

TABLE 81.—Results of digestion experiments Nos. 81-98.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 81.</i>						
109	Pumpkin	Grams. 1,692.0	Grams. 32.74	Grams. 3.16	Grams. 223.97	Grams. 22.11	Grams. 10.63
	Shoyu	90.0	α 4.77				
	Total		32.74	3.16	223.97	22.11	10.63
	Feces, fresh	74.5	3.70	1.06	3.31	.42	1.77
	Amount digested		29.04	2.10	220.66	21.69	8.86
	Per cent digested		88.7	66.5	(98.5)	98.1	83.4
	<i>Experiment No. 82.</i>						
114	Taro	1,045.0	14.76	3.54	146.55	7.89	10.46
	Shoyu	150.0	α 6.95				
	Total		14.76	3.54	146.55	7.89	10.46
	Feces, fresh	138.0	7.43	1.89	7.69	1.20	3.14
	Amount digested		7.33	1.65	138.86	6.69	7.32
	Per cent digested		49.7	46.5	(94.8)	84.8	70.0
	<i>Experiment No. 83.</i>						
118	Yam	1,043.0	16.10	2.42	125.20	9.01	7.90
	Shoyu	90.0	α 4.77				
	Total		16.10				
	Feces, fresh	96.0	6.80	1.28	4.45	1.12	2.18
	Amount digested		9.30	1.14	120.75	7.89	5.72
	Per cent digested		57.8	48.1	(96.4)	87.6	62.4
	<i>Experiment No. 84.</i>						
112	<i>Stachys sieboldi</i>	1,135.0	14.40	2.30	239.86	9.00	14.11
	Shoyu	40.0	α 2.12				
	Total		14.40	2.30	239.86	9.00	14.11
	Feces, fresh	148.0	8.28	1.74	10.15	1.25	3.68
	Amount digested		6.12	.56	229.71	7.75	10.43
	Per cent digested		42.5	24.2	(95.8)	86.1	74.0
	<i>Experiment No. 85.</i>						
108	Potatoes	1,120.0	16.65	.73	194.41	4.39	10.44
	Shoyu	90.0	α 4.77				
	Total		16.65	.73	194.41	4.39	10.44
	Feces, fresh	374.5	18.49	4.33	16.51	1.85	7.24
	Amount digested				177.90	2.54	3.20
	Per cent digested				(91.5)	57.9	30.7
	<i>Experiment No. 86.</i>						
102	Lily bulb	890.0	8.62	.78	80.25	3.05	4.33
	Shoyu	100.0	α 5.30				
	Total		8.62	.78	80.25	3.05	4.33
	Feces, fresh	126.0	15.29	4.05	18.81	1.36	3.08
	Amount digested				61.44	1.69	1.25
	Per cent digested				(76.6)	55.3	28.8
	<i>Experiment No. 87.</i>						
92	Arrowhead	827.0	30.70	2.34	171.64	5.36	10.26
	Shoyu	90.0	α 4.77				
	Total		30.70	2.34	171.64	5.36	10.26
	Feces, fresh	96.0	2.95	.65	4.44	.56	1.91
	Amount digested		27.75	1.69	167.20	4.80	8.35
	Per cent digested		90.4	72.14	(97.4)	89.5	81.4

α Not included in the total.

TABLE 81.—Results of digestion experiments Nos. 81–98—Continued.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N × 6.25).	Fat.	Carbo- hydrates (including fiber).	Crude fiber.	Ash.
	<i>Experiment No. 88.</i>						
103	Lotus rhizome.....	Grams. 938.0	Grams. 11.55	Grams. 0.74	Grams. 95.14	Grams. 12.62	Grams. 6.90
	Shoyu.....	90.0	a 4.77				
	Total.....		11.55	.74	95.14	12.62	6.90
	Feces, fresh.....	171.0	4.31	.88	8.17	2.27	1.92
	Amount digested.....		7.24		86.97	10.35	4.98
	Per cent digested.....		62.7		(91.4)	82.0	72.2
	<i>Experiment No. 89.</i>						
59	Fu (kingyo).....	229.0	131.34	2.24	59.23	.41	2.04
	Shoyu.....	150.0	a 7.95				
	Total.....		131.34	2.24	59.23	.41	2.04
	Feces, fresh.....	116.0	10.49	1.70	8.64	.28	.57
	Amount digested.....		120.85	.54	50.59	.13	1.47
	Per cent digested.....		92.01	24.2	(85.4)	32.3	71.9
	<i>Experiment No. 90.</i>						
60	Fu (kiri).....	280.0	77.24	1.31	90.52	.22	1.84
	Shoyu.....	90.0	a 4.77				
	Total.....		77.24	1.31	90.52	.22	
	Feces, fresh.....	57.0	4.90	1.02	6.62	2.28	1.19
	Amount digested.....		72.34	.29	83.90		.65
	Per cent digested.....		93.7	21.9	(92.7)		35.2
	<i>Experiment No. 91.</i>						
56	Biscuit.....	526.0	23.93	1.53	464.64	1.17	4.60
	Shoyu.....	30.0	a 1.59				
	Total.....		23.93	1.53	464.64	1.17	4.60
	Feces, fresh.....	204.0	14.60	3.05	11.92	.75	4.41
	Amount digested.....		9.33		452.72	.42	.20
	Per cent digested.....		39.0		(97.5)	35.8	4.1
	<i>Experiment No. 92.</i>						
89	Tofu.....	1,519.0	88.57	66.99	18.95		10.83
	Shoyu.....	150.0	a 7.95				
	Total.....		88.57	66.99	18.95		10.83
	Feces, fresh.....	88.0	9.59	3.18	.34		4.85
	Amount digested.....		78.98	63.81	18.61		5.98
	Per cent digested.....		89.2	95.3	(98.2)		55.2
	<i>Experiment No. 93.</i>						
90	Tofu cake.....	850.0	57.77	19.61	58.10	20.66	6.33
	Shoyu.....	140.0	a 7.42				
	Total.....		57.77	19.61	58.10	20.66	6.33
	Feces, fresh.....	81.5	12.31	3.07	10.01	2.14	4.52
	Amount digested.....		45.46	16.54	48.09	18.52	1.81
	Per cent digested.....		78.7	84.3	(82.8)	89.6	28.6
	<i>Experiment No. 94.</i>						
91	Yuba.....	151.0	72.02	30.78	24.95	.54	2.45
	Shoyu.....	70.0	a 3.71				
	Total.....		72.02	30.78	24.95	.54	2.45
	Feces, fresh.....	21.27	5.36	1.33	3.28	.35	1.96
	Amount digested.....		66.66	29.45	21.67	.19	.49
	Per cent digested.....		92.6	95.7	(86.8)	35.5	19.8

a Not included in the total.

TABLE 81.—Results of digestion experiments Nos. 81-98—Continued.

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein. (N×6.2).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
<i>Experiment No. 95.</i>							
72	Konnyaku.....	Grams. 844.0	Grams. 0.63	Grams. 0.06	Grams. 24.53	Grams. 3.19	Grams. 2.84
	Shoyu.....	80.0	a 4.24				
	Bonito sauce.....	175.0	a. 53				
	Total.....		.63	.06	24.53	3.19	2.84
	Feces, fresh.....	45.0	2.25	.68	4.42	.40	1.08
	Amount digested.....				20.11	2.79	1.76
	Per cent digested.....				82.0	87.4	61.9
<i>Experiment No. 96.</i>							
68	Katakuri starch made from <i>Ery- thronium dens-canis</i>	149.0	.81	.06	113.25		.39
	Shoyu.....	10.0	.53				
	Table salt (little).....						
	Total.....		.81	.06	113.25		
	Feces, fresh.....	40.0	1.60	.90	4.92		.40
	Amount digested.....				108.33		
	Per cent digested.....				95.7		
<i>Experiment No. 97.</i>							
69	Kuzu starch made from <i>Pueraria thunbergiana</i>	140.0	.95	.06	114.21		.38
	Salt.....						
	Total.....		.95	.06	114.21		
	Feces, fresh.....	43.0	2.77	.95	3.87		.33
	Amount digested.....				110.34		
	Per cent digested.....				96.6		
<i>Experiment No. 98.</i>							
99	Dried gourd.....	107.0	4.79	.66	64.74	7.21	4.81
	Shoyu.....	100.0	a 5.30				
	Total.....		4.79		64.74	7.21	4.81
	Feces, fresh.....	41.0	2.70	.84	3.93	.57	1.17
	Amount digested.....		2.09		60.81	6.64	3.64
	Per cent digested.....		43.6		(93.9)	92.1	76.7

a Not included in the total.

DIGESTION EXPERIMENTS WITH SWEET POTATOES (Nos. 99 and 100).

These experiments were made by Y. Kaji, ^a at the Army Medical College, Tokyo. Each experiment continued three days, beginning June 18, 1897. The subjects of both were laboratory servants, in experiment No. 99, K. Y., 50 years old, weighing 45.88 kilograms at the beginning and 45.23 kilograms at the end, and in No. 100, K. K., 30 years old, weighing 45.5 kilograms at the beginning and 46.63 kilograms at the end. The diet in both experiments consisted of sweet potatoes, prepared by removing the skin and cooking the edible material with shoyu in one case, and shoyu and salt in the other. For the separation of the feces, black sesame seed was employed with good result.

^a Gun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1899, No. 3, p. 134.

Samples of food and feces were analyzed, the results being included in Tables 6 and 64. Crude fiber was determined in the food but not in the feces.

TABLE 82.—*Digestion experiments Nos. 99 and 100.*

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 99.</i>						
113	Sweet potato ^a	<i>Grams.</i> 1,987.0	<i>Grams.</i> 33.98	<i>Grams.</i> 15.10	<i>Grams.</i> 1,641.66	<i>Grams.</i> 45.70
	Shoyu.....	270.0	<i>b</i> 13.50			
	Total.....		33.98	15.10	1,641.66	45.70
	Feces ^a	90.0	30.93	6.48	38.88	9.88
	Amount digested.....		3.05	8.62	1,602.78	35.82
	Per cent digested.....		9.0	57.1	(97.6)	78.4
<i>Experiment No. 100.</i>						
113	Sweet potato ^a	2,338.06	39.98	17.77	1,931.70	53.78
	Shoyu (with salt).....	120.0	<i>b</i> 16.00			
	Total.....		39.98	17.77	1,931.70	53.78
	Feces ^a	87.1	35.66	8.61	30.28	8.92
	Amount digested.....		4.32	9.16	1,901.42	44.86
	Per cent digested.....		10.8	51.6	98.5	83.4

^a The total weight is that of partially dried material.

^b Not included in the total.

DIGESTION EXPERIMENT WITH AN ARMY RATION (No. 101).

This experiment formed part of an investigation of the ration of a provision corps in the army. (See p. 97.) The subject was the investigator himself, S. Nagao, ^a an army surgeon, weighing 54 kilograms. The experiment continued four days, but the date is not given in the original report. The food consisted of the ordinary army ration, a mixed diet, the principal item being a rice-barley mixture. For the separation of the feces raw red mungo bean was used and the lines of demarcation were very satisfactory. The percentage composition of the food and feces was not reported.

TABLE 83.—*Results of digestion experiment No. 101.*

Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
Beef, fish, rice-barley, legumes, and vegetables.....	<i>Grams.</i> 9,510	<i>Grams.</i> 368.0	<i>Grams.</i> 55.4	<i>Grams.</i> 2,085.1	<i>Grams.</i> 98.0
Total.....		368.0	55.4	2,085.1	98.0
Feces (water-free).....	170	50.6	25.5	76.9	17.0
Amount digested.....		317.4	29.9	2,008.2	81.0
Per cent digested.....		86.2	54.0	96.3	(82.6)

^a Gun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1899, No. 103, p. 493.

DIGESTION EXPERIMENTS WITH RICE GRUEL (Nos. 102-104).

These experiments were conducted by Ito,^a under the direction of Washitsu, at Fukuoka Military Hospital, for the purpose of determining the digestibility of rice gruel, which is often used as a diet for weak patients who require light food. Each experiment continued three days, but the dates were not given.

The proportions of rice and water used in preparing the gruel varied. In experiment No. 102 it was 153 grams of rice boiled with 1,000 cubic centimeters of water, the weight after cooking being 741 grams; in experiment No. 103 it was 107 grams of rice boiled with 700 cubic centimeters of water, the weight after cooking being 519 grams; in experiment No. 104 it was 72 grams of rice boiled with 500 cubic centimeters of water, the weight after cooking being 408 grams. Although in the original report no reference was made to salt, it is very probable that a certain quantity was used in the gruel. The average amount of gruel eaten by patients was taken as the measure of the ration allowance in these experiments.

The subjects were not patients but male nurses employed in the hospital. In experiment No. 102 the subject weighed 49.69 kilograms at the beginning and 48.38 kilograms at the end of the experiment. In experiment No. 103 the subject weighed 61.39 kilograms at the beginning and 60.38 kilograms at the end. In experiment No. 104 the subject weighed 52.58 kilograms at the beginning and 50.78 kilograms at the end.

A sample of the gruel used in each experiment was analyzed, the composition being given in Table 6. The feces also were analyzed in each case, but the percentage composition was not reported. In analyzing the feces the fat was not determined. It was therefore impossible to calculate the coefficients of digestibility of fat and carbohydrates separately. The quantity of fat in the diet of gruel was very small, however, and probably it was quite thoroughly digested, so that the coefficient of digestibility as computed for both fat and carbohydrates together may be considered as representing, at least approximately, the value for carbohydrates alone.

Three additional experiments with rice gruel were reported, but they were not of such a character that they could be included in the present compilation.

^aGun-igakukwai Zasshi (Jour. Army Med. Soc.), Tokyo, 1901, No. 120, p. 331.

TABLE 84.—Results of digestion experiments Nos. 102–104.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 102.</i>						
50	Rice gruel.....	<i>Grams.</i> 5,967.0	<i>Grams.</i> 75.6	<i>Grams.</i> 928.7	<i>Grams.</i> 5.4	<i>Grams.</i> 5.6
	Feces (water-free).....	50.6	29.3	15.7	5.6	5.6
	Amount digested.....		46.3	913.0		
	Per cent digested.....		61.2	98.3		
<i>Experiment No. 103.</i>						
51	Rice gruel.....	4,671.0	75.6	689.5	10.2	10.2
	Feces (water-free).....	46.3	29.8	10.4	6.1	6.1
	Amount digested.....		45.8	679.1	4.1	4.1
	Per cent digested.....		60.0	98.5		
<i>Experiment No. 104.</i>						
52	Rice gruel.....	3,672.0	35.7	409.0	2.9	2.9
	Feces (water-free).....	49.6	19.1	29.7	.8	.8
	Amount digested.....		16.6	379.3	2.1	2.1
	Per cent digested.....		46.5	92.7		

DIGESTION EXPERIMENTS WITH VEGETABLE FOODS (Nos. 105–112).

These experiments were made by J. Murai and D. Kasama, army surgeons, at the Army Medical College, Tokyo, and reported by K. Makiyama,^a during the months of September to December, 1898, though the exact date of each was not given in the original report. Each experiment continued one day. The ages and weights of the subjects were not reported.

Only the edible portion of various food materials was used. Samples of the food and feces were analyzed according to the usual methods. The results of the analyses are given in Tables 6 and 64.

The amount of protein in the shoyu used was given in the original tables, but was not included in calculating the coefficients of digestibility of the protein of the diet, on the assumption that the protein of the shoyu was completely digested. The ash in shoyu was also ignored, although the amount was relatively large. Shoyu ash consists principally of sodium chlorid, which was assumed to be completely absorbed and excreted in the urine, and therefore to be omitted in computing the digestibility of the mineral matters of the diet. For the same reason the table salt used was always ignored in the calculation of results. The figures in parentheses in the tables were computed by the compiler.

Experiment No. 105.—The subject was J. M., one of the investigators. The diet consisted of eggplant with the outer skin not removed. For separating the feces buckwheat and raw red mungo beans were used, but the results were not very satisfactory.

^aGun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1902, No. 4, p. 211.

Experiment No. 106.—The subject was D. K., one of the investigators. The diet consisted of dried fern (*Osmunda regalis japonica*), which had been soaked in water for one day. For the separation of the feces buckwheat flour, raw red adzuki beans, and red pepper were used, but the results were not entirely satisfactory.

Experiment No. 107.—The subject was J. M., one of the investigators. The diet consisted of fried taro stem previously soaked in water for twelve hours. For separating the feces buckwheat flour, raw red adzuki beans, and red pepper were used, but the separation was not entirely satisfactory.

Experiment No. 108.—The subject was J. M., one of the investigators. The diet consisted of gourd (*Lagenaria* sp.). A good separation of the feces was obtained by the use of buckwheat flour with raw peas and red pepper skin.

Experiment No. 109.—The subject was D. K., one of the investigators. The diet consisted of carrots. A good separation of the feces was obtained by the use of buckwheat flour and raw red adzuki beans.

Experiment No. 110.—The subject was J. M., one of the investigators. The diet consisted of radish (*Rhaphanus sativus*). Sweet potatoes and red pepper skin were used for the separation of the feces, but the result was not very satisfactory.

Experiment No. 111.—The subject was K. Y., a laboratory servant. The diet consisted of edible burdock root. Buckwheat flour and red pepper skin were used for the separation of the feces with very good results.

Experiment No. 112.—The subject was N., an army surgeon. The diet consisted of dried mushroom (*Agaricus sitake*). A satisfactory separation of the feces was obtained by the use of buckwheat flour.

TABLE 85.—Results of digestion experiments Nos. 105–112.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 105.</i>						
97	Eggplant	Grams. 621.7	Grams. 5.16	Grams. 0.62	Grams. 36.43	Grams. 5.22	Grams. 3.23
	Shoyu	90.0	a 6.23				
	Total		5.16	.62	36.43	5.22	3.23
	Feces	33.43	6.06	1.07	5.15	.95	2.23
	Amount digested				31.28	4.27	1.00
	Per cent digested				(85.9)	81.8	34.0
	<i>Experiment No. 106.</i>						
107	Fern, dried (<i>Osmunda regalis</i>)	49.3	16.57	2.22	49.20	13.21	2.70
	Shoyu	49.3	a 3.41				
	Total		16.57	2.22	49.20	13.21	2.70
	Feces	13.7	13.13	2.97	12.08	1.16	3.34
	Amount digested		3.44		37.12	12.05	
	Per cent digested		20.3		(75.5)	90.8	

a Not included in the total.

TABLE 85.—Results of digestion experiments Nos. 105–112—Continued.

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
<i>Experiment No. 107.</i>							
115	Taro stem, dried.....	Grams. 363.5	Grams. 2.14	Grams. .58	Grams. 46.44	Grams. 13.89	Grams. 3.42
	Shoyu.....	80.0	a 4.43				
	Total.....		2.14	.58	46.44	13.89	3.42
	Feces.....	48.0	4.95	1.56	7.70	4.68	2.33
	Amount digested.....				38.74	9.21	1.09
	Per cent digested.....				(83.4)	66.3	31.9
<i>Experiment No. 108.</i>							
98	Gourd.....	1,269.6	12.69	1.02	27.42	8.63	11.43
	Shoyu.....	70.0	a 4.84				
	Total.....		12.69	1.02	27.42	8.63	11.43
	Feces.....	6.60	10.25	2.36	5.50	2.49	3.42
	Amount digested.....		2.44		21.92	6.14	8.01
	Per cent digested.....		19.2		(79.9)	71.2	70.0
<i>Experiment No. 109.</i>							
95	Carrots.....	555.0	4.77	1.83	41.08	6.22	4.88
	Shoyu.....	60.0	a 4.15				
	Total.....		4.77	1.83	41.08	6.22	4.88
	Feces.....	66.0	3.48	.94	1.98	.40	1.16
	Amount digested.....		1.29	.89	39.10	5.82	3.72
	Per cent digested.....		27.0	48.6	(95.2)	93.2	76.2
<i>Experiment No. 110.</i>							
110	Radish.....	1,293.5	16.17	1.68	77.35	20.82	13.19
	Shoyu.....	60.0	a 4.15				
	Total.....		16.17	1.68	77.35	20.82	13.19
	Feces.....	64.0	5.11	1.57	2.29	.52	1.61
	Amount digested.....		11.06	.11	75.06	20.30	11.58
	Per cent digested.....		68.4	6.5	(97.1)	97.6	87.8
<i>Experiment No. 111.</i>							
94	Edible burdockroot (<i>Arctium lappa</i>).....	259.0	8.99	.52	45.32	5.54	2.30
	Shoyu.....	40.0	a 2.77				
	Total.....		8.99	.52	45.32	5.54	2.30
	Feces.....	55.0	6.75	1.12	3.34	1.03	1.90
	Amount digested.....		2.24		41.98	4.51	.40
	Per cent digested.....		24.9		(92.6)	81.4	17.4
<i>Experiment No. 112.</i>							
104	Mushroom, dried.....	74.0	11.66	1.43	44.30	10.69	3.19
	Shoyu.....	40.0	a 3.46				
	Total.....		11.66	1.43	44.30	10.69	3.19
	Feces.....	101.0	9.43	2.27	7.21	.97	2.43
	Amount digested.....		2.23		37.09	9.72	.76
	Per cent digested.....		19.1		(83.7)	90.9	28.8

a Not included in the total.

DIGESTION EXPERIMENTS WITH RICE IN COMBINATION WITH OTHER
FOOD MATERIALS (Nos. 113–125).

These experiments were also made by Murai and Kasama at the Army Medical College, and reported by K. Makiyama, a during the

a Gun-i Gakko Gyofu (Bul. Army Med. Col.), Tokyo, 1902, No. 4, p. 211.

months of February to May, 1900, though the particular date of the individual experiments was not mentioned in the original report.

The details regarding methods, etc., were in general the same as in experiments Nos. 105-112, though the majority of the present experiments were of longer duration. In experiments Nos. 113-116 the diet consisted of a single food material, with shoyu; but in Nos. 117-125 rice was also included in the diet in each case. The results actually obtained in these experiments are values for the digestibility of the nutrients of a diet consisting of rice and the particular food of the experiment, but from the data it is possible to calculate also the digestibility of the latter alone. For this purpose the results of experiment No. 113 with rice may be taken as a basis. The amount of each ingredient in the feces from the mixed diet that would be due to the rice was computed by use of the values obtained in this experiment and deducted from the total amount of the given ingredient of the feces from the mixed diet, and the difference was assumed to represent the amount undigested from the food other than rice. In all the experiments, however, the nutrients of the shoyu and sugar used were entirely neglected, as usual, on the assumption that they would be completely digested. The original figures computed according to such assumption have been retained.

Experiment No. 113.—This experiment continued five days. The subject was J. M., one of the investigators. The diet consisted of rice. For the separation of the feces whole buckwheat flour and raw red mungo beans were used, but the results were not entirely satisfactory.

Experiment No. 114.—This experiment continued three days. The subject was J. M., one of the investigators. The diet was rolled barley. For the separation of the feces whole buckwheat flour and raw red mungo beans were used, but the results were not entirely satisfactory.

Experiment No. 115.—This experiment continued one day. The subject was D. K., one of the investigators. The diet consisted of dried marine algæ (*Ecklonia bicyclis*). For the separation of the feces powdered charcoal was used previous to the experiment, but the result was not entirely satisfactory.

Experiment No. 116.—This experiment continued one day. The subject was J. M., one of the investigators. The diet consisted of dried marine algæ (*Laminaria* sp.). For the separation of the feces powdered charcoal was used, but the results were not very good.

Experiment No. 117.—This experiment continued four days. The subject was D. K., one of the investigators. The diet consisted of cracked barley with rice. Buckwheat and raw red mungo beans were used for separating the feces with fairly good results.

Experiment No. 118.—This experiment continued three days. The subject was A., an army surgeon. The diet consisted of dried marine algæ (*Laminaria* sp.) with rice. For the separation of the feces buckwheat flour and raw red mungo beans were used with satisfactory results.

Experiment No. 119.—This experiment continued two days. The subject was H., an army surgeon. The diet consisted of dried marine algæ (*Ulopteryx pinnatifida*) with rice. For separating the feces buckwheat flour and raw red mungo beans were used, but the result was not entirely satisfactory.

Experiment No. 120.—This experiment continued two days. The subject was K., an army surgeon. The diet consisted of poulpe (*Octopus octopodia*) with rice. The poulpe was cooked with small amounts of shoyu and sugar, though the amounts were not given in the original. For the separation of the feces buckwheat flour and raw red mungo beans were used with very good results.

Experiment No. 121.—This experiment continued three days. The subject was J. M., one of the investigators. The diet consisted of shellfish (*Tapes philippinarum*) with rice. For the separation of the feces raw red mungo beans were used previous to the experiment and orange seeds at the end, but the separation was not entirely satisfactory.

Experiment No. 122.—This experiment continued three days. The subject was J. M., one of the investigators. The diet consisted of dried fish (*Decapterus muroadsi*) with rice. A satisfactory separation of the feces was obtained by the use of buckwheat and sesame seed at the beginning and of buckwheat and red pepper skin at the end of the experiment.

Experiment No. 123.—This experiment continued three days. The subject was D. K., one of the investigators. The diet consisted of dried fish (kusaya-aji, a kind of Carangidæ) with rice. A very satisfactory separation of the feces was obtained by the use of buckwheat flour and pickled radish.

Experiment No. 124.—This experiment continued three days. The subject was K., an army surgeon. The diet consisted of kamaboko (a preparation of dab flesh and wheat flour, described on p. 20) with rice. For separating the feces buckwheat flour and raw red mungo beans were used, but the results were not entirely satisfactory.

Experiment No. 125.—This experiment continued two days. The subject was D. K., one of the investigators. The diet consisted of bamboo shoots with rice. A satisfactory separation of the feces was obtained by the use of buckwheat flour and pickled radish.

TABLE 86.--Results of digestion experiments Nos. 113-125.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
<i>Experiment No. 113.</i>							
48	Rice.....	Grams. 2,360.0	Grams. 93.22	Grams. 13.92	Grams. 1,815.08	Grams. 6.61	Grams. 7.55
	Salt.....	35.0					
	Total.....		93.22	13.92	1,815.08	6.61	7.55
	Feces.....	125.0	27.85	6.14	10.50	2.75	5.02
	Amount digested.....		65.37	7.78	1,804.58	3.86	2.53
	Per cent digested.....		67.4	55.9	(99.4)	57.5	33.6
<i>Experiment No. 114.</i>							
38	Rolled barley.....	1,800.0	130.50	4.32	1,250.46	28.44	22.14
	Shoyu.....	646.0		a 4.49	a 3.11		
	Total.....		130.50	4.32	1,250.46	28.44	22.14
	Feces.....	253.0	30.75	16.98	25.96	5.29	12.15
	Amount digested.....		99.75		1,224.50	23.15	9.99
	Per cent digested.....		76.4		97.9	81.4	45.1
<i>Experiment No. 115.</i>							
96	Dried algæ (<i>Ecklonia bicyclis</i>).....	67.3	3.34	.27	22.05	12.90	4.21
	Shoyu.....	50.0	a 3.46	a .38			a 9.38
	Sugar.....	20.0			a 9.46		
	Total.....		3.34	.27	22.05	12.90	4.21
	Feces.....	108.0	1.26	.90	14.07	10.60	4.14
	Amount digested.....		2.08		7.98	2.30	.07
	Per cent digested.....		62.3		(36.2)	17.8	1.7
<i>Experiment No. 116.</i>							
101	Dried algæ (<i>Laminaria</i> sp.).....	73.0	2.04	.35	16.64	2.40	4.14
	Shoyu.....	35.0	a 2.42	a .26	a 1.69		a 6.57
	Total.....		2.04	.35	16.64	2.40	4.14
	Feces.....	40.0	2.01	2.75	7.49	.83	3.16
	Amount digested.....		.03		9.15	1.57	.98
	Per cent digested.....		1.5		(55.0)	(65.4)	23.7
<i>Experiment No. 117.</i>							
48	Cleaned rice.....	1,844.5	72.86	10.88	1,418.60	5.16	5.90
39	Cracked barley.....	631.5	45.09	.95	432.32	7.70	4.23
	Shoyu.....	70.0	a 4.84	a .53	a 3.38		a 13.14
	Total.....		117.95	11.83	1,850.92	12.86	10.13
	Feces, total.....	258.0	38.80	13.27	7.56	4.57	6.60
	Estimated feces from rice.....		21.76	4.80	8.21	2.16	3.93
	Estimated feces from barley.....		17.04	8.47	b 2.41	2.41	2.67
	Amount digested:						
	From total food.....		79.15		1,843.36	8.29	3.53
	From barley alone.....		28.05		429.91	5.29	1.56
	Per cent digested:						
	From total food.....		67.1		99.6	64.5	34.9
	From barley alone.....		62.2		99.4	(68.7)	36.9
<i>Experiment No. 118.</i>							
100	Dried algæ (<i>Laminaria</i> sp.).....	123.38	5.07	1.78	43.10	6.48	8.09
48	Cleaned rice.....	1,400.00	55.20	8.26	1,074.74	3.92	4.48
	Shoyu.....	50.0	a 3.46	a .38	a 2.41		a 9.38
	Total.....		60.27	10.04	1,117.84	10.40	12.57
	Feces, total.....	398.5	45.27	9.56	16.94	4.54	9.84
	Estimated feces from rice.....		16.52	3.64	6.23	1.64	2.98
	Estimated feces from algæ.....		28.75	5.92	10.71	2.90	6.86

a Not included in the total.

b It was evidently assumed that nitrogen-free extract in barley was wholly digestible

TABLE 86.—Results of digestion experiments Nos. 113-125—Continued.

Anal- ysis refer- ence No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
<i>Experiment No. 118—Continued.</i>							
48	Amount digested:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	From total food.....		15.00	0.48	1,100.90	5.86	2.73
	From algae alone.....				32.39	3.58	1.23
	Per cent digested:						
	From total food.....		(24.9)	(4.8)	(98.4)	(56.3)	(21.8)
	From algae alone.....				(75.2)	55.3	15.2
<i>Experiment No. 119.</i>							
117	Dried algae (<i>Ulopteryx pinnatifida</i>).....	255.0	2.78	.82	92.64	6.68	19.05
48	Cleaned rice.....	1,500.0	49.25	8.85	1,153.65	4.20	4.80
	Shoyu.....	150.0	a 10.38	a 1.14	a 7.23		a 28.15
	Sugar.....	27.8			a 27.05		
	Total.....		52.03	9.67	1,246.29	10.88	23.85
	Feces.....	398.5	34.23	5.93	31.86	8.24	11.03
	Estimated feces from rice.....		17.70	3.90	6.67	1.75	3.19
	Estimated feces from algae.....		16.53	2.03	25.18	6.49	7.84
	Amount digested:						
	From total food.....		17.80	3.74	1,214.43	2.64	12.82
	From algae alone.....				67.46	.19	11.21
	Per cent digested:						
	From total food.....		(34.2)	(38.7)	(97.4)	(24.3)	(53.8)
	From algae alone.....				(72.8)	2.8	58.9
<i>Experiment No. 120.</i>							
24	Poulpe, cooked.....	694.0	153.51	10.27			18.88
48	Rice, cleaned.....	1,340.0	52.93	7.91	1,030.59		4.29
	Total.....		206.44	18.18	1,030.59		23.17
	Feces.....	9.9	16.71	7.61	7.27		3.76
	Estimated feces from rice.....		15.81	3.49			2.85
	Estimated feces from poulpe.....		.90	4.12			.91
	Amount digested:						
	From total food.....		189.73	10.57	1,023.32		19.41
	From poulpe alone.....		152.61	6.15			17.97
	Per cent digested:						
	From total food.....		(91.9)	(58.1)	(99.3)		(83.8)
	From poulpe alone.....		99.5	60.0			95.2
<i>Experiment No. 121.</i>							
30	Shellfish (<i>Tapes philippinarum</i>).....	2,143.0	273.45	23.14			44.79
48	Rice, cleaned.....	1,250.0	49.37	7.37	961.38		4.00
	Shoyu.....	52.0	a 3.60	a .40			a 9.75
	Sugar.....	11.5			a 10.20		
	Total.....		322.82	30.51	961.38		58.54
	Feces.....	132.0	22.40	6.82	3.74		4.87
	Estimated feces from rice.....		14.75	3.43			2.80
	Estimated feces from fish.....		7.65	3.39			2.07
	Amount digested:						
	From total food.....		300.42	23.69	957.64		53.67
	From shellfish alone.....		265.80	19.75			42.72
	Per cent digested:						
	From total food.....		(93.1)	(77.6)	(99.6)		(91.7)
	From shellfish alone.....		97.2	(85.3)			95.4
<i>Experiment No. 122.</i>							
20	Dried fish (<i>Decapterus muroadsi</i>).....	456.7	284.11	19.64			94.54
48	Rice, cleaned.....	1,740.0	68.73	10.27	1,338.23		5.57
	Total.....		352.84	29.91	1,338.23		100.11

a Not included in the total.

TABLE 86.—Results of digestion experiments Nos. 113-125—Continued.

Anal- ysis reference No.	Kind of food.	Weight of material.	Protein (N×6.25).	Fat.	Carbo- hydrates (includ- ing fiber).	Crude fiber.	Ash.
	<i>Experiment No. 122—Continued.</i>						
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	
	Feces.....	113.5	22.89	6.59	12.86		9.41
	Estimated feces from rice.....		20.53	4.52			3.71
	Estimated feces from fish.....		2.36	2.07			5.70
	Amount digested:						
	From total food.....		329.95	23.32	1,325.37		90.70
	From dried fish alone.....		281.75	(17.57)			88.84
	Per cent digested:						
	From total food.....		(93.5)	(78.0)	(99.0)		(90.6)
	From dried fish alone.....		99.2	89.5			94.0
	<i>Experiment No. 123.</i>						
22	Dried fish (kusaya-aji).....	432.0	237.69	15.12			61.00
48	Rice, cleaned.....	1,800.0	71.10	10.62	1,384.18		5.96
	Total.....		308.79	25.74	1,384.18		66.96
	Feces.....	300.0	47.40	12.71	7.46		9.26
	Estimated feces from rice.....		21.24	4.68			3.83
	Estimated feces from fish.....		26.16	8.03			5.43
	Amount digested:						
	From total food.....		261.39	13.03	1,376.72		57.70
	From dried fish alone.....		211.53	7.09			55.57
	Per cent digested:						
	From total food.....		(84.7)	(50.6)	(99.5)		(86.2)
	From dried fish alone.....		89.0	46.9			91.1
	<i>Experiment No. 124.</i>						
34	Kamaboko.....	2,234.0	496.62	55.85	76.82		44.68
48	Rice, cleaned.....	1,400.0	55.30	8.26	1,076.74		4.48
	Shoyu.....	117.0	α 8.10	α .89	α 5.64		α 21.96
	Total.....		551.92	64.11	1,153.56		49.16
	Feces.....	178.0	31.84	9.59	8.77		7.21
	Estimated feces from rice.....		16.52	3.64	6.23		2.98
	Estimated feces from kama- boko.....		15.32	5.95	2.54		4.23
	Amount digested:						
	From total food.....		520.08	54.52	1,144.79		41.95
	From kamaboko alone.....		481.30	49.90	74.28		40.45
	Per cent digested:						
	From total food.....		(94.2)	(85.0)	(99.2)		(85.3)
	From kamaboko alone.....		96.9	89.4	96.7		90.5
	<i>Experiment No. 125.</i>						
93	Bamboo shoot.....	2,128.0	60.22	35.32	62.36	18.31	16.60
48	Rice, cleaned.....	1,400.0	55.30	8.26	1,076.74	3.92	4.48
	Shoyu.....	100.0	α 6.92	α .76	α 4.82		α 18.77
	Sugar.....	30.0			α 26.61		
	Total.....		115.52	43.58	1,139.10	22.23	21.08
	Feces.....	464.0	33.96	6.64	11.69	4.17	7.15
	Estimated feces from rice.....		16.52	3.64	6.23	1.64	2.98
	Estimated feces from bamboo shoot.....		17.44	3.00	5.46	2.53	4.17
	Amount digested:						
	From total food.....		81.56	36.94	1,127.41	18.06	13.93
	From bamboo shoot alone.....		42.78	32.32	56.90	15.78	12.43
	Per cent digested:						
	From total food.....		(70.6)	(84.8)	(99.0)	(81.2)	(66.1)
	From bamboo shoot alone.....		71.1	91.5	(91.2)	86.2	74.9

α Not included in the total.

INCOMPLETE DIGESTION EXPERIMENTS.

As explained on page 101, the digestibility of the protein, but not of the other nutrients, was determined in connection with a number of dietary studies. Such data are summarized in Table 87. The conditions under which the experiments were made are noted in the descriptions given below.

Experiments Nos. 20-28.—These were made by Kumagawa in connection with dietary experiments Nos. 27-30 (see p. 101). In these experiments the feces passed within twenty-four hours after the last meal (supper) were considered as pertaining to the food of the preceding day. The quantities for the different days were very irregular, and only the total weight of feces during a given experimental period has been considered. The nitrogen in feces was determined by the Kjeldahl method.

Experiments Nos. 28-36.—These were made by Amaya and Kirisawa, in connection with dietary experiments Nos. 35-42 (see p. 105).

For the separation of the feces, lampblack was used in all the experiments except Nos. 34 and 36. In these two cases the feces voided on the morning of the first experimental day were regarded as pertaining to food eaten previous to the experiment and were not included, and the feces voided on the morning following the last day of the experiment were regarded as pertaining to the food of the experimental period. After the weight of the fresh feces was obtained a small amount of dilute sulphuric acid was added to the material, which was then thoroughly mixed and dried, first in a steam bath and finally at 100-110° C. Nitrogen was determined by the Kjeldahl method.

Urine was collected every twenty-four hours and the nitrogen determined in the daily sample. A little chloroform was added to each sample as a preservative.

Experiments Nos. 37-43.—These were made by Taniguchi, in connection with dietary experiments Nos. 59-65 (see p. 111). Feces were collected in each experiment and the proportion of nitrogen determined.

Experiments Nos. 44-50.—These were made by Oi, in connection with dietary experiments Nos. 67-73 (see p. 113).

The data of the digestion experiments are summarized in the following tables. In Table 87 the quantity of protein given is the total for the whole experiment in each case, whereas in the experiments in Table 88 the average quantity per day is given.

TABLE 87.—Results of digestion experiments Nos. 20-23 and 28-36.

Digestion experiment No. <i>a</i>	Corre- sponding dietary No.	Refer- ence No.	Subject.			Dura- tion.	Kind of food.	Protein (N × 6.25) —			
			Occupation.	Weight—				In food.	In feces.	Amount digested.	Coeffi- cient of digesti- bility.
At be- ginning.	At end.	Grams.		Grams.	Grams	Per cent					
20	27	14	Physician.....	Kilos. 48.70	Kilos. 49.15	Days. 13	Rice, meat, fish, eggs, and vegetables.....	1,174.0	181.6	992.4	(84.5)
21	28	14	do.....	48.60	48.00	5	Rice, fish, and vegetables.....	200.0	56.3	233.7	(80.6)
22	29	14	do.....	48.61	48.25	9	Rice, and vegetables.....	221.0	51.9	169.1	(76.5)
23	30	14	do.....	48.47	48.86	5	do.....	492.3	114.2	378.1	(76.8)
28	35	17	Laboratory assistant.....	43.10	42.80	10	Rice, meat, fish, and vegetables.....	835.6	107.5	728.1	(87.1)
29	36	18	Physician.....	49.50	49.50	7	do.....	553.1	64.7	488.4	(88.3)
30	37	19	Laboratory assistant.....	42.90	42.80	7	Rice, fish, and vegetables.....	512.4	61.6	450.8	(88.0)
31	37a	19	do.....	42.80	43.15	6	do.....	439.2	61.8	377.4	(85.9)
32	38	20	do.....	43.00	42.70	10	Rice, legumes, and vegetables.....	828.7	143.2	685.5	(82.7)
33	39	21	do.....	43.90	43.30	5	Rice and vegetables.....	238.0	54.2	183.8	(77.2)
34	40	22	do.....	42.35	42.25	7	do.....	366.8	83.1	283.7	(77.3)
35	41	23	Physician.....	49.55	49.55	8	do.....	402.4	127.6	274.8	(68.3)
36	42	14	do.....	49.90	49.50	6	do.....	336.0	75.4	260.6	(77.6)

a Corresponding nitrogen-metabolism experiments have the same number.

TABLE 88.—*Results of digestion experiments Nos. 37-50.*
[Amounts of protein per man per day.]

Digestion experiment No. ^a	Corresponding dietary No.	Reference No.	Subject.		Duration.	Kind of food.	Protein (N × 6.25) —			
							In food.	In feces.	Amount digested.	Coefficient of digestibility.
			Occupation.	Weight— At beginning.	At end.					
				Kilos.	Kilos.	Days.	Grams.	Grams.	Grams.	Per cent.
37	59	25	Laboratory servant.....	44.00	43.80	2	89.4	5.7	63.7	(91.8)
38	60	25	do.....	43.70	43.70	4	64.6	14.4	50.2	(77.7)
39	61	25	do.....	43.70	44.10	4	64.6	14.4	66.5	(82.2)
40	62	25	do.....	43.00	43.20	10	80.9	12.5	47.6	(79.2)
41	63	25	do.....	43.00	43.10	10	60.1	13.1	52.7	(80.0)
42	64	25	do.....	43.40	43.10	10	65.8	11.9	52.8	(81.6)
43	65	25	do.....	43.30	45.00	10	64.7	15.0	50.0	(76.9)
44	67	26	do.....	43.40	43.20	5	65.0	2.6	125.3	97.2
45	68	26	3 nurses.....	b 60.7	b 60.7	3	127.9	2.6	74.5	96.2
46	69	26	do.....	b 60.7	b 60.7	3	75.1	.5	49.6	96.1
47	70	26	do.....	b 60.7	b 60.7	3	50.0	7.4	127.8	94.6
48	71	26	do.....	b 60.7	b 60.7	3	135.2	8.7	130.8	93.8
49	72	26	do.....	b 60.7	b 60.7	3	139.5	8.6	78.1	90.0
50	73	26	do.....	b 60.7	b 60.7	3	86.7	1.0	60.9	98.4

^a Corresponding nitrogen-metabolism experiments have the same number.

^b Average weight of 3 persons.

SUMMARY AND DISCUSSION OF RESULTS.

The results of the digestion experiments are here summarized in groups, the experiments of similar nature being brought together, and some deductions are drawn regarding the digestibility of the nutrients in Japanese animal and vegetable food materials.

It will be observed that, in accordance with common usage, what is here considered as the digestibility of a nutrient is the difference between the quantity in the food eaten and that in the corresponding feces. It has, of course, been pointed out by different investigators^a that this represents apparent but not actual digestibility, since to determine the latter it is necessary to make allowance for the so-called metabolic products of feces (see p. 199), which are not undigested residues of food. The data here considered, however, are those commonly reported in investigations on the digestibility of food.

EXPERIMENTS WITH ANIMAL FOOD.

FISH.

The only animal food of importance in the Japanese diet in general is fish. The results of eight experiments with fish and one with a preparation of fish are here summarized:

TABLE 89.—Summary of results of digestion experiments with fishes.

Digestion experiment No.	Kind of food.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo-hydrates
	<i>Fresh fish.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
9	Porgy (<i>Pagrus major</i>)	97.7	73.2	.....
10	Salmon	98.0	93.8	.....
^a 120	Poulpe (<i>Octopus octopodia</i>)	99.5	^b 60.0	.....
^b 121	Shellfish (<i>Tapes philippinarum</i>)	97.2	85.3	.....
	Average	98.1	84.1	.....
	<i>Dried fish.</i>			
11	Herring	92.9	80.2	.....
12	Cod	95.3	.....	.....
122	<i>Decapterus muroadsi</i>	99.2	89.5	.....
^a 123	Kusaya-aji (<i>Carangidæ</i>)	^b 89.0	^b 46.9	.....
	Average	95.8	84.8	.....
	Average of all	97.1	84.4	.....
^a 124	Kamaboko (preparation of fish and wheat flour) ^c	96.9	89.4	96.7

^a Estimated from digestibility of total food.

^b Accuracy uncertain and not included in average.

^c See the description on page 20.

In the experiments on the digestibility of the nutrients of fish the amounts of protein consumed each day were such that any error due to the presence of small amounts of metabolic products in the feces

^a See, for example, Atwater and Bryant, Connecticut Storrs Station Rpt. 1899, p. 69.

would not materially affect the results. The average digestibility of the protein of fresh fish was found to be 98 per cent, whereas that for dried fish was 95.8 per cent. Possibly in the case of the dried fish the cooking did not render it as accessible to the digestive juices as was the case with the fresh fish. As a matter of fact, in experiments Nos. 11 and 12 the feces from the diets containing dried cod and dried herring contained small fragments of undigested fish, showing that some of the fish flesh had escaped the action of the digestive juices.

The results regarding the digestibility of fat are very discordant. In those experiments in which the amount of fat eaten was small the coefficient of digestibility of fat was low. This may very probably be accounted for largely by the error introduced by metabolic products of the feces which are soluble in ether. The amount of fat in the diet being small, even small amounts of ether-soluble metabolic products would have a relatively large effect upon the apparent digestibility, resulting in a low coefficient; therefore not much importance can be given the results of experiments in which the diet contained a small amount of fat. For example, in an experiment with dried cod when the subject obtained only 1 gram of fat per day from the diet about 35 per cent more ether extract was present in the feces than in the food. On the other hand in experiments with salmon, which is a fat fish, a coefficient of digestibility as high as 93.8 per cent was obtained.

This matter is also considered in the discussion of the ether extract of metabolic products in feces, page 204.

EXPERIMENTS WITH CEREALS.

The results of experiments with cereals and cereal preparations are summarized here:

TABLE 90.—*Summary of results of digestion experiments with cereals and cereal preparations.*

Digestion experiment No.	Kind of food.	Coefficients of digestibility.			
		Protein	Fat.	Carbo-hydrates (including crude fiber).	Crude fiber.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
4	Rice, cooked.....	79.0	^a 24.7	99.5	.....
5	do.....	81.2	^a 44.4	99.5	.....
113	do.....	67.4	^a 55.0	90.4	57.5
	Average.....	75.9		90.5	.....
19	Glutinous rice cake.....	64.2		99.9	.....
74	Glutinous rice cake, dried.....	86.4	76.1	99.8	.....
	Average.....	75.3		99.9	.....
102	Rice gruel.....	61.2	98.3		.....
103	do.....	60.6	98.5		.....
104	do.....	46.5	92.7		.....
	Average.....	56.1	96.5		.....

^a Accuracy uncertain and not included in average

TABLE 90.—*Summary of results of digestion experiments with cereals and cereal preparations—Continued.*

Digestion experi- ment No.	Kind of food.	Coefficients of digestibility.			
		Protein.	Fat.	Carbo- hydrates (includ- ing crude fiber).	Crude fiber.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Barley, cooked.....	^a 40.2		^a 90.9	^a 58.9
2	do.....	51.9		95.0	
3	do.....	48.6		94.5	60.6
114	Rolled barley, cooked.....	76.4		97.9	81.4
117	Cracked barley, cooked.....	62.2		99.4	68.7
	Average.....	59.8		96.7	70.2
75	Buckwheat.....	74.3	^a 5.9	96.8	
76	do.....	76.3	76.4	97.2	
	Average.....	75.3		97.0	
77	Macaroni.....	94.3	86.1	99.2	
78	do.....	93.2	82.3	99.3	
	Average.....	93.6	84.2	99.3	
79	Vermicelli.....	89.0	75.6	98.7	
80	do.....	87.0	79.6	98.6	
	Average.....	88.0	77.6	98.7	
89	Fu (gluten preparation) ^b	92.0	^a 24.2	85.4	32.3
90	Fu (gluten preparation) ^b	93.7	^a 21.9	92.7	
	Average.....	92.9		89.1	
91	Biscuit ^c	^a 39.0		97.5	35.8

^a Accuracy uncertain and not included in average.^b See the description on page 20.^c Crackers, probably pilot bread.

RICE.

The digestibility of protein in rice ranged in different experiments from 64 to 86 per cent, and is decidedly lower than the result for protein in macaroni or in fu (a gluten preparation). Hardly any difference in digestibility was found between the ordinary rice and the glutinous rice. In experiments with rice gruel the digestibility of protein was low, but this was due possibly to unavoidable experimental errors ascribable to metabolic products rather than to actual differences in digestibility of protein. The carbohydrates of rice appear to be quite thoroughly digested. Among all the cereals the coefficient of digestibility of carbohydrates was largest in the case of rice.

BARLEY.

The coefficient of digestibility of protein in barley was very low, being about 15 per cent less than that of rice. The carbohydrates of barley were also less completely digested than those of rice, though the differences are not so large as in the case of protein. It should be observed that these experiments, with the exception of No. 117, were made with single food materials, and barley is a very poor material

for such a diet because of its physical nature and lack of palatability. The decortication of barley is usually not as thorough as in the case of rice. As commonly used, either the whole or the cracked grain is cooked with water always in combination with rice; but, as pointed out above, in these experiments barley was eaten alone. Not only did the coarse physical nature of the grain apparently render it more resistant to the action of the digestive juices, but the intervals between successive times of defecation were comparatively short, indicating that the barley increased the peristaltic action so that the material was hastened along through the intestine, which would tend to lessen the efficiency of the digestive functions. For instance, in experiment No. 1 the intervals of defecation range from four to twenty hours, averaging eleven hours. The very low digestibility in this experiment may doubtless be explained in part by this fact.

OTHER CEREALS THAN RICE AND BARLEY.

The digestibility of protein in macaroni, fu, and vermicelli decreased in the order mentioned, though in these wheat preparations the protein was on an average quite thoroughly digested. It is interesting to compare the digestibility of carbohydrates of two different preparations of fu in experiments Nos. 89 and 90. In the former experiment the material was of a coarser nature and contained nearly twice as much crude fiber as that in the latter and the digestibility of the carbohydrates was appreciably smaller.

The quantity of fat in these experiments with cereals varied from 1.3 to 7.6 grams, and the coefficients of digestibility are in general so variable as to render most of them of little significance.

EXPERIMENTS WITH LEGUMES.

Of all the vegetable foods commonly used the legumes are much the richest in protein. Since they are an important source of protein in the diet of the people living so largely upon vegetable foods as the Japanese, the digestibility of the nutrients of legumes is of special interest. The results of experiments with these food materials are summarized in Table 91.

TABLE 91.—*Summary of results of digestion experiments with legumes and legume preparations.*

Digestion exper- iment No.	Kind of food.	Coefficients of digestibility.			
		Protein.	Fat.	Carbo- hydrates (includ- ing crude fiber).	Crude fiber.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
6	Beans, dried.....	61.8	^a 34.7	81.4	25.0
7	do.....	69.1	^a 37.8	89.9	36.8
	Average.....	65.5	.....	85.7	30.9
8	Tofu ^b	96.1	97.4	88.4	.....
92	do.....	89.2	95.3	98.2	.....
	Average.....	92.7	96.4	93.3	.....
94	Yuba (soy legumin coagulated) ^b	92.6	95.7	86.8	35.5
93	Tofu cake (soy-bean residue) ^b	78.7	84.3	82.8	89.6

^a Accuracy uncertain.^b See the description on page 26.

In experiments Nos. 6 and 7 the skin or outer coating of the beans used was purposely not removed in cooking, since, according to the investigators, the general custom among the Japanese people is to leave the skins on. The crude fiber in the matured seed is not easily digested and the proportions actually digested in these experiments were low. The presence of the indigestible crude fiber (amounting in these cases to over 4 per cent of the total dried material of the bean) apparently exerted considerable influence upon the digestibility of the other nutrients, the coefficients for the protein and fat being decidedly lower than in the case of the legume preparations, and those for carbohydrates being also comparatively low. The quantities of protein and fat furnished by the beans in these experiments were so large that the possible error due to metabolic products should have a relatively small effect upon the result.

In experiments Nos. 6 and 7 cane sugar was eaten in addition to the beans. If it is assumed that the sugar was completely digested, and may therefore be entirely deducted from the carbohydrates of the diet, the coefficients of digestibility of the carbohydrates of the beans alone would be, respectively, 73.7 and 82.1 per cent instead of 81.4 and 89.9 per cent, as given in the table. In comparison with the results of other experiments with beans, the coefficients of digestibility obtained in these experiments were decidedly low. Thus Snyder^a found that on an average 80.2 per cent of the protein, 79.8 per cent of the fat, and 96.2 per cent of the carbohydrates of baked beans were digested.

The amount of cooked beans eaten per day was 374 grams in experiment No. 6, and 232 grams, or nearly 38 per cent less, in

^a Minnesota Station Bul. 74.

experiment No. 7. Apparently the digestibility was larger in the experiment with the smaller amount of beans.

It should be stated in regard to these experiments that the intervals of defecation were short, especially in experiment No. 6, in which they ranged from 4 to 12 hours and averaged 7 hours. In No. 7 the range was from 9 to 23.5 hours and averaged 14 hours. When the food material remained so short a time in the intestine, the digestive process might very probably have been incomplete.

In contrast with the results of the experiments with the beans themselves, the results obtained in the experiments with the bean preparations are noticeably larger. As regards the several tests the coefficient for carbohydrates in experiment No. 8 is noticeably lower than that in experiment No. 22. The amount of carbohydrates in the former experiment, however, was small, and so any experimental errors would materially affect the results.

It is interesting to compare the coefficients actually obtained in these experiments with a tofu diet and those estimated from the results of experiments Nos. 16-18 with tofu-rice diets by assuming certain factors for the digestibility of the rice. For such estimates the coefficient of digestibility of protein of rice has been assumed as 81, 85, and 90 per cent, respectively. The value 81 per cent was obtained from the results of all the digestion experiments with cereals. The value 90 per cent is probably as high a value as can be reasonably assumed in any case. According to the calculations by use of these factors the digestibility of the protein of the tofu in the tofu-rice diet was 95 to 98 per cent, which agrees with the result obtained in experiment No. 8. In a similar manner the digestibility of fat in tofu may be estimated from the rice diet, and the coefficients thus computed would be 93 to 97 per cent, or values similar to those in experiments Nos. 8 and 92. These coefficients agree well with those for similar nutrients in animal foods. Little can be learned regarding the digestibility of carbohydrates of tofu from the results of the tofu-rice diet, because the quantity of carbohydrates supplied by the tofu was very small.

All these results seem to substantiate the view of Prausnitz^a that the differences between animal and vegetable food in respect to digestibility of nutrients are due, not so much to any fundamental differences in the nature of the nutrients as to the physical condition of the food materials, or, in other words, the digestibility is probably influenced very largely by the method of preparation.

^aZtschr. Biol., 35 (1897), p. 335.

EXPERIMENTS WITH STARCHES AND KONNYAKU.

The results of two experiments with starch and one with konnyaku are here tabulated.

TABLE 92.—Summary of results of digestion experiments with starches and konnyaku.

Digestion experiment No.	Kind of food.	Coefficients of digestibility.			
		Protein.	Fat.	Carbo-hydrates (including crude fiber).	Crude fiber.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
96	Starch (from <i>Erythronium dens-canis</i>)			95.7	
97	Starch (from <i>Pueraria thunbergiana</i>)			96.6	
	Average			96.2	
95	Konnyaku ^a			82.0	^b 87.4

^a Prepared from *Hydrosme rivieri* (*Conophallus konjak*) tuber. See the description on page 35.

^b Accuracy uncertain.

The carbohydrate of konnyaku, which is mannan, is of a different nature from starch, and according to the figures in the table above it was noticeably less thoroughly digested. The amounts of protein and fat obtained from these foods were so small that the results have no real value.

EXPERIMENTS WITH VEGETABLES.

The results of Japanese digestion experiments with vegetables are summarized in the following table:

TABLE 93.—Summary of results of digestion experiments with vegetables.

Digestion experiment No.	Kind of food.	Coefficients of digestibility.			
		Protein.	Fat.	Carbo-hydrates (including crude fiber).	Crude fiber.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
	<i>Fresh vegetables.</i>				
87	Arrowhead	90.4	72.1	97.4	89.5
^a 125	Bamboo shoot	71.1	91.5	91.2	86.2
111	Burdock	^b 24.9		92.6	81.4
109	Carrots	^b 27.0	^b 48.6	95.2	93.2
105	Eggplant			^b 85.9	81.8
108	Gourd	^b 19.2		^b 79.9	71.2
86	Lily bulb			^b 76.6	55.3
88	Lotus rhizome	62.7		91.4	82.0
85	Potatoes			91.5	57.7
81	Pumpkins	88.7	^b 66.5	98.5	^b 98.1
110	Radish	68.4	^b 6.5	97.1	^b 97.6
84	Stachys tuber (<i>Stachys sieboldi</i>)	^b 42.5	^b 24.2	95.8	86.1
99	Sweet potatoes	^b 9.0	^b 57.1	97.6	
100	do	^b 10.8	^b 51.6	98.5	
82	Taro	^b 49.7	^b 46.5	94.8	84.8
83	Yam (<i>Dioscorea</i> sp.)	^b 57.8	^b 48.1	96.4	87.6
	Average	^c 72.3		^d 95.2	^e 79.7

^a Estimated from digestibility of total food.

^b Accuracy uncertain and not included in average.

^c Average 5 experiments

^d Average 13 experiments.

^e Average 12 experiments.

TABLE 93.—Summary of results of digestion experiments with vegetables—Continued.

Digestion experiment No.	Kind of food.	Coefficients of digestibility			
		Protein.	Fat.	Carbo- hydrates (includ- ing crude fiber).	Crude fiber.
	<i>Dried vegetables.</i>				
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
106	Fern (<i>Osmunda regalis</i>).....	a 20.3	.....	75.5	a 90.8
112	Mushroom.....	a 19.1	.....	83.7	a 90.9
107	Taro stem.....	.....	.....	83.4	66.3
	Average.....	.....	.....	b 80.8	.....
98	Kampyo c.....	a 43.6	.....	93.9	92.1
	<i>Dried marine algæ.</i>				
115	<i>Ecklonia bicyclis</i>	62.3	.....	a 36.2	a 17.8
d 118	<i>Laminaria</i> sp.....	.....	.....	75.2	55.3
116	do.....	a 1.5	.....	55.0	a 65.4
d 119	<i>Ulopteryx pinnatifida</i>.....	.....	.....	72.8	a 2.8
	Average.....	.....	.....	b 67.7	.....

a Accuracy uncertain and not included in average.

b Average 3 experiments.

c Edible portion of *Lagenaria vulgaris* cut into thin slips and dried.

d Estimated from digestibility of total food.

Nearly all of the common vegetables contain very small quantities of either protein or fat. Their value as food depends almost entirely upon the carbohydrates which they contain, although they provide bulkiness in the diet, supply valuable mineral matters, and help to make the diet palatable.

Very little can be learned from the results of such experiments as these with a diet of single food materials regarding the digestibility of protein and of fat in vegetable foods, the amounts of these ingredients supplied being so small that the unavoidable experimental error is relatively too large to warrant any reliable conclusions. The amount of protein eaten per day in these experiments ranged from 2 to 32.7 grams and averaged 12.3 grams, and that of fat ranged from 0.3 to 5.9 grams and averaged 1.8 grams.

With respect to carbohydrates, however, the conditions are different. In the average of 13 experiments with fresh vegetables the coefficient of digestibility of carbohydrates was 95.2 per cent, though in the case of eggplant, gourd, and lily bulb it was much lower than this. In the experiments with dried vegetables, such as dried fern, mushroom, and taro stem, the proportion digested was also relatively low. The results obtained with the dried marine algæ vary considerably, the digestibility of carbohydrates ranging from 36.2 to 75.2 per cent and averaging 67.7 per cent. As explained in the description of these products on page 34, the nature of the carbohydrates in them is in general different from that in ordinary vegetables. The number and nature of the experiments with these materials here

summarized, however, are such that general conclusions are not warranted from the results obtained.

The coefficient of the digestibility of crude fiber averaged in 12 experiments with fresh vegetables 79.7 per cent and ranged from 53 to 93 per cent. The fiber in growing plants is of a different nature from that in the mature plants, the ligno-cellulose in the mature plant being much harder to digest than hydro-cellulose in the growing plant. The average digestibility of fiber in these 12 experiments as compared with the coefficient of 30.9 per cent in the average of the two experiments, Nos. 6 and 7, with dried legumes is decidedly interesting.

EXPERIMENTS WITH VARIOUS DIETS.

The following tables summarize the results of digestion experiments with various diets composed of mixed vegetables and vegetable and animal foods.

TABLE 94.—*Summary of results of digestion experiments with mixed-vegetable diet.*

Digestion experiment No.	Kind of food.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo-hydrates.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
22	Rice and vegetables	76.5		
23	do	76.8		
24	do	80.7		98.7
32	Rice, beans, and vegetables	82.7		
33	Rice and vegetables	77.2		
34	do	77.3		
35	do	68.3		
36	do	77.6		
38	do	77.7		
39	Rice and miso	82.2		
40	Rice and vegetables	79.2		
41	do	80.0		
42	do	81.6		
43	do	76.9		
46	do	^a 99.1		
125	Rice and bamboo shoot	70.6	84.8	99.0
118	Rice and algæ	^a 24.9	^a 4.8	98.4
119	do	^a 34.2	^a 38.7	97.4
	Average	^b 77.7		^c 98.4
15	Rice, barley, and vegetables	75.7		96.6
50	do	^a 98.4		
117	Rice and barley	67.1		99.6

^a Accuracy uncertain and not included in average.

^b Average of 15 experiments.

^c Average of 4 experiments.

TABLE 95.—*Summary of results of digestion experiments with mixed vegetables and animal diet.*

Digestion experiment No.	Kind of food.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo- hydrates.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13	Rice, meat, milk, and vegetables.....	90.2		99.3
14	Rice, fish, and vegetables.....	87.3		99.6
20	Rice, meat, milk, and vegetables.....	84.5		
21	Rice, fish, and vegetables.....	80.6		
25	Rice, meat, fish, and vegetables.....	90.2	81.8	99.5
26	do.....	80.4	89.5	
27	do.....	84.3	92.0	96.8
28	do.....	87.1		
29	do.....	88.3		
30	Rice, fish, and vegetables.....	88.0		
31	do.....	85.9		
37	Rice and beef extract.....	a 91.8		
44	Rice and fish.....	97.2		
51	Rice, meat, fish, and vegetables.....	85.3		b 98.1
52	do.....	85.5		b 98.3
53	do.....	84.4		b 98.8
54	do.....	81.4		b 98.2
55	do.....	82.9		b 99.0
56	do.....	83.4		b 98.6
64	Bread, rice, meat, fish, and vegetables.....	78.7		b 96.3
65	do.....	78.4		b 96.9
66	do.....	82.1		b 97.1
67	do.....	82.2		b 97.4
68	do.....	83.0		b 96.7
69	do.....	82.1		b 96.4
70	Rice, fish, and vegetables.....	97.3		b 96.9
71	Rice, bread, meat, and vegetables.....	97.4		b 96.5
72	Rice, milk, and pickles.....	85.5	92.6	99.5
73	Rice, "health," and pickles.....	80.3	82.1	99.5
120	Rice and fish.....	91.9	a 58.1	99.3
121	Rice and shellfish.....	93.1	77.6	99.6
122	Rice and dried fish.....	93.5	78.0	99.0
123	do.....	84.7	a 50.6	99.5
124	Rice and fish preparation.....	94.2	85.0	99.2
Average.....		c 86.4	d 84.8	e 98.2

a Accuracy uncertain and not included in average.

b Compare the explanation in the description of the experiments, Nos. 51-69 and Nos. 70-71.

c Average of 33 experiments.

d Average of 8 experiments.

e Average of 25 experiments.

TABLE 96.—*Summary of results of digestion experiments with mixed vegetable and animal diet containing barley.*

Digestion experiment No.	Kind of food.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo- hydrates.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
47	Barley, rice, and meat.....	94.6		
48	Barley, rice, and fish.....	93.8		
57	Barley, rice, meat, fish, and vegetables.....	72.7		a 96.8
58	do.....	73.7		a 96.5
59	do.....	74.4		a 96.5
60	do.....	61.2		a 96.6
61	do.....	75.0		a 96.4
62	do.....	67.2		a 96.8
63	Barley, meat, fish, and vegetables.....	61.2		a 87.9
101	Barley, rice, meat, fish, and vegetables.....	86.2	b 54.0	96.3
Average.....		c 76.0		d 96.6

a Compare the explanation in the descriptions of the experiments Nos. 51-69

b Accuracy uncertain and not included in average.

c Average of 10 experiments.

d Average of 7 experiments

TABLE 97.—*Summary of results of digestion experiments with cereals and tofu.*

Digestion experiment No.	Kind of food.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo-hydrates.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
16	Rice and tofu	95.2	96.5	98.3
17	Rice, tofu, and vegetable oil	94.2	93.9	99.5
18	Rice, tofu, starch, and sugar	95.2	94.8	98.8
45	Rice and tofu	99.2		
	Average	^a 95.9	^b 95.1	^b 98.9
49	Rice, barley, and tofu	90.0		

^a Average of 4 experiments. ^b Average of 3 experiments.

The digestibility of the protein in the diet of mixed vegetables, averaging about 78 per cent, was decidedly lower than in that of vegetable and animal foods, which averaged about 86 per cent. The superiority of the latter is due to the higher digestibility of the animal foods used. On the other hand, in the experiments with vegetable diet consisting of cereals and tofu, the digestibility of the protein, averaging 96 per cent, was decidedly larger even than that of the animal and vegetable diet.

The number of experiments in which satisfactory results for the digestibility of fat were obtained is very small, and few deductions therefore can be drawn from the data regarding the digestibility of vegetable fat in the Japanese dietaries. The most interesting figures are those in the experiments with the cereal and tofu diet, which indicate that under favorable circumstances as much as 95 per cent of the vegetable fat may be digested and assimilated.

The digestibility of the carbohydrates is nearly the same in all diets, though lowest in the diets containing barley.

RICE AND BARLEY DIET.

Barley is seldom if ever used alone in the Japanese dietary, but as it is employed quite frequently as a substitute for part of the rice of the diet, the results obtained with the diets containing barley are interesting. The following figures summarize the data that may be compared:

TABLE 98.—*Comparison of digestibility of nutrients in rice and barley diets.*

Kind of food.	Coefficients of digestibility.		
	Protein.	Fat.	Carbo-hydrates.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Rice	75.9		99.5
Barley	59.8		96.7
Mixed vegetable and animal diet without barley	86.4		98.2
Mixed vegetable and animal diet with barley	76.0		96.6
Rice and tofu diet	95.9		98.8
Rice, barley, and tofu diet	90.0		

In every parallel case, the digestibility of both the protein and the carbohydrates was lower in the diet containing barley than in the corresponding diet without it. This would apparently indicate that barley is not altogether a desirable substitute for rice.

It is worthy of note that by those who use the rice-barley diet it is commonly believed to be more easily digested than the rice diet. In this connection two facts must be taken into account. In the first place, as ordinarily cooked, there is a difference between the amount of water in boiled barley and that in boiled rice. The boiled barley used in the experiments of Osawa and Ueda, for example, contained in the average of 18 analyses 76.3 per cent of water, whereas in the same series of experiments boiled rice contained in the average of 24 analyses 65.8 per cent of water, indicating that boiled barley retains about 10 per cent more water than boiled rice. The significance of this fact is apparent when it is remembered that the amount of such food consumed is usually regulated by the feeling of satiety or, in other words, the same individual under normal circumstances would eat about the same volume of two different foods of somewhat similar character. If, then, the same person should eat the same volume of boiled barley at one time as of boiled rice at another, he would be taking in his diet more water in the former case than in the latter—that is, in the barley diet the bulk of actual food material would be about a tenth smaller, and there would therefore be that much less material to be disposed of in the stomach; now, if both kinds of food were actually digested with equal ease, the barley diet would probably be disposed of more rapidly because of the smaller bulk. The sensation of hunger in that case would occur sooner and so might give rise to the idea that the barley diet was the more easily digested.

On the other hand, as before mentioned, the coarsely ground barley would tend to stimulate peristalsis and increase the rapidity of the passage of the material through the alimentary canal. This also might help account for the idea that the barley diet was the more quickly digested, but in reality it more probably is the reason why the proportions of nutrients actually digested from the barley diet are smaller than from the rice diet. Barley, it seems fair to say, is an important food for people who are in need of some such stimulating action in peristalsis, but aside from this it can not profitably be substituted for rice.

GENERAL SUMMARY OF DIGESTIBILITY.

From the data given in the preceding pages the figures believed to be the most satisfactory are here gathered together, showing in condensed form the average digestibility of nutrients in different classes of Japanese food materials, and in vegetable and mixed diets.

TABLE 99.—*Summary of average digestibility of nutrients in different classes of food and in mixed diets.*

Kind of food.	Number of experiments included in average.	Coefficients of digestibility.		
		Protein.	Fat.	Carbo-hydrates.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Vegetables, fresh.....	5-13	72.3		95.2
Vegetables, dried.....	3			80.8
Marine alga, dried.....	3			67.7
Beans, dried.....	2	65.5		85.7
Tofu.....	(2)	92.7	96.4	93.3
Tofu cake (soy-bean residue).....	(1)	78.7	84.3	82.8
Yuba (soy legumin coagulated).....	(1)	92.6	95.7	86.8
Starches.....	2			96.2
Konnyaku.....	1			82.0
Barley.....	4	59.8		96.7
Buckwheat.....	(2)	75.3		97.0
Rice.....	3	75.9		99.5
Glutinous rice cake.....	(2)	75.3		99.6
Macaroni.....	(2)	93.6	84.2	99.3
Vermicelli.....	(2)	88.0	77.6	98.7
Fu (gluten preparation).....	(2)	92.9		89.1
Biscuit (crackers).....	(1)			97.5
Fish, fresh.....	4-3	98.1	84.1	
Fish, dried.....	3	95.8	84.8	
Fish, average of all.....	(7-4)	97.1	84.4	
Kamaboko (fish preparation).....	1	96.9	89.4	96.7
Vegetables, mixed diet.....	(15-4)	77.7		98.4
Rice and tofu diet.....	4-3-3	95.9	95.1	98.9
Rice, barley, and tofu diet.....	1	90.0		
Mixed vegetable and animal diet without barley.....	33-18-25	86.4	84.8	98.2
Mixed vegetable and animal diet with barley.....	10-7	76.0		96.6

No additional comment on these figures is required here, since they are discussed in the preceding sections.

METABOLIC PRODUCTS IN FECES.

Reference has been made previously (p. 187) to the metabolic products of feces. Since the quantities of the ingredients of the metabolic products have an important relation to the results of digestion experiments, and as certain of the Japanese experiments throw some light upon this subject, it seems worth while to consider this topic here.

The portion of the feces which is commonly designated by the term metabolic products includes not only the residues from the bile, mucous, saliva, gastric, and pancreatic juices, and other digestive secretions, but also particles from the mucous membrane of the intestine and various excretory products. The results of recent investigations, especially those by Prausnitz, Moeller, and by Kermayer,^a indicate that the quantities of metabolic products in the feces are relatively quite large as compared with the quantity of actually undigested food under normal circumstances. Observations by Kobert and Koch^b on the excretory substances from the large intestine in a case of anus praeternaturalis, and the calorimetric investigations of feces by Rubner^c also tend to indicate the same thing.

^a Ztschr. Biol., 35 (1897), p. 329.

^c Ztschr. Biol., 42 (1901), p. 300.

^b Deut. Med. Wehnschr., 1894, p. 833.

Several methods for determining the nitrogen in the metabolic products have been suggested. Schulze and Maercker^a attempted to determine metabolic nitrogen by treating the feces successively with boiling alcohol and boiling ether. This method was shown to give results that are not very reliable. Stutzer^b proposed to determine metabolic nitrogen by digesting feces with freshly prepared pepsin solution. This method was modified and improved by Pfeiffer.^c Woods and Merrill^d at the Maine Agricultural Experiment Station have employed this method and also one in which the feces are treated successively with ether, alcohol, water, and lime-water. The results obtained by the latter method do not accord very closely with those obtained by the Stutzer-Pfeiffer method.^e

Experiments have been made, many of them with animals, especially dogs, to study the composition of feces when the diet contains practically no nitrogen, and also during fasting. It was believed that if no nitrogen was consumed the nitrogen in the feces must pertain to metabolic products. The results obtained during the fasting period, however, are considered not applicable to the period when food is consumed. In this connection the work of F. Voit^f and of Tsuboi^g is of interest.

In the above summary attention is called only to the results of a number of experiments with men under normal conditions, i. e., when food was eaten.

ARTIFICIAL DIGESTION OF FECES.

Nitrogen.—Kajita^h treated the feces of three of the subjects of his experiments according to Pfeiffer's modified method and obtained the following results:

TABLE 100.—*Results of artificial digestion experiments with feces.*

Sub- ject.	Diet.	Nitrogen.		
		Total in feces.	Not di- gested.	In meta- bolic products.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
A	Rice, pickled radish, shoyu, nori	2.01	0.51	1.50
B	Rice, bonito, shoyu, perilla seeds	.98	.30	.68
C	Rice, shoyu	.55	.25	.30

With the feces from subject A four determinations were made, and with those from B and C three each. As will be seen from the

^a Jour. Landw., 19 (1871), p. 46.

^b Ztschr. Physiol. Chem., 10 (1886), p. 153.

^c Ztschr. Physiol. Chem., 10 (1886), pp. 170 and 561.

^d Maine Station Rpts. 1887, p. 128; 1888, p. 210; 1889, p. 282.

^e See U. S. Dept. Agr., Office of Experiment Stations Bul. 85, pp. 36, 37.

^f Ztschr. Biol., 29 (1893), p. 325.

^g Ztschr. Biol., 35 (1897), pp. 68-93.

^h Tokyo Igakukai Zasshi (Jour. Tokyo Med. Soc.), 4 (1890), pp. 550 and 676.

figures there was considerable variation in the quantity of nitrogen assumed to be derived from metabolic products in these experiments.

Woods and Merrill^a treated the feces from a diet of bread or milk according to two different methods. In the feces treated with pepsin solution they obtained on the average per day 2.07 grams of nitrogen from metabolic products, as compared with 1.01 grams obtained by successive treatment with ether, alcohol, hot water, and lime-water, or nearly twice as much by the former method as by the latter.

Jaffa,^b employing the method of successive treatment with ether, alcohol, hot water, and limewater, found 0.55 gram of metabolic nitrogen per day in the feces of a girl 6 years old living largely on fruit.

Parkes,^c in experiments with men upon diets that contained no nitrogenous substances and 50 per cent of the diet consisting of sugar, found 0.4 to 0.6 gram of nitrogen per day in the feces. However, he did not make an actual separation of the feces pertaining to this diet; hence the accuracy of the results can not be determined.

Rubner^d found 1.39 grams of nitrogen per day in feces from a diet containing 1.36 grams per day. He considered that the larger part of this nitrogen of the feces came from the residues of the digestive juices.

Rieder^e found in three experiments with diets consisting of nitrogen-free starch, sugar, and fat, 0.54, 0.78, and 0.87 gram of nitrogen per day in the feces.

Woods and Merrill,^a in an experiment with a diet consisting of tapioca, sugar, salt, etc., and containing 1.4 grams nitrogen per day, found that the feces contained 0.62 gram nitrogen per day, and concluded that this amount of nitrogen was from metabolic products.

In eight Japanese digestion experiments in which the foods contained very little or practically no nitrogenous substances the following results were obtained:

TABLE 101.—Amount of nitrogen per day in food and feces in several Japanese experiments.

Whence obtained.	Nitrogen.		Whence obtained.	Nitrogen.	
	In food.	In feces.		In food.	In feces.
	Grams.	Grams.		Grams.	Grams.
Experiment No. 95	0.10	0.36	Experiment No. 115	0.54	0.20
Experiment No. 96	.13	.26	Experiment No. 109	.76	.56
Experiment No. 97	.15	.44	Experiment No. 98	.77	.43
Experiment No. 116	.33	.32			
Experiment No. 107	.34	.79	Average	.39	.42

The amounts of nitrogen in the feces from different experiments are remarkably similar, and in the experiments cited are apparently independent of the amount of nitrogen in the food. The larger part,

^a Loc. cit.

^b U. S. Dept. Agr., Office of Experiment Stations Bul. 107, p. 23.

^c Proc. Roy. Soc. [London], 89 (1867), p. 94.

^d Ztschr. Biol., 15 (1879), p. 199.

^e Ztschr. Biol., 20 (1884), p. 389.

if not all, of this nitrogen in the feces therefore must have been derived from metabolic products.

The results of such experiments as have been considered above seem to indicate that from 0.3 to 0.9 gram of nitrogen per day will be found in feces from diets containing very little or practically no nitrogenous substances. The absolute amount of nitrogen due to metabolic products in feces, however, must depend largely upon the kind and amount of food eaten. Experiments made by Pfeiffer^a with swine, and by Tsuboi^b with dogs fed nitrogen-free food indicate that the amount of nitrogenous metabolic products in feces is proportional to the amount of dry material digested or consumed.

On the other hand, there is reason to believe that the amount of metabolic products in the feces depends also upon the physical nature of the food taken, as will appear from a consideration of the amount of metabolic ether extract in feces.

Ether extract.—The amount of ether extract in feces voided by both men and other animals during fasting has been found to be considerable. Experiments made by F. Voit^c with dogs have shown that when food is taken the amount is larger than during fasting, but apparently very few experiments have been made to determine the amount of ether extract in feces with practically fat-free diet. Rubner,^d in experiments with men, found 3.1 to 6.5 grams of ether extract in feces from a diet which was almost free from fat, and considered this as approximately the amount of ether extract due to intestinal secretions. In the Japanese digestion experiments Nos. 95, 96, and 97, the food contained only 0.06 gram ether extract in each experiment, whereas in the feces 0.68, 0.91, and 0.95 gram, respectively, were found. The average amount, 0.85 gram, in these experiments may be considered as derived from residues of digestive juices or other metabolic products.

The influence of the physical nature of the food in increasing the secretion of digestive juices, and consequently increasing the amount of ether extract in the feces, is well illustrated by the following results from Japanese digestion experiments:

TABLE 102.—Amount of dry matter in food and of ether extract in food and feces per day in several Japanese experiments.

Experiment No.	Kind of food.	Total dry matter in food.	Ether extract.	
			In food.	In feces.
		Grams.	Grams.	Grams.
77	Macaroni.....	564	3.5	0.5
78	do.....	457	2.5	.5
79	Vermicelli.....	367	2.3	.6
80	do.....	368	3.0	.6
114	Barley.....	469	1.4	5.7
1	do.....	453	5.5	9.2
2	do.....	425	5.4	9.7
3	do.....	379	5.1	8.5

^a Jour. Landw., 38 (1885), p. 166.

^b Zeitschr., Biol., 35 (1897), p. 68.

^c Ztschr. Biol., 29 (1893), p. 354.

^d Ztschr. Biol., 15 (1879), p. 191.

The differences in the amounts of total dry material in the different experiments were probably not so great as to cause any large difference in the amount of intestinal secretion. In the experiments with macaroni the amounts of ether extract in the feces were even smaller than those found in experiments Nos. 95-97, mentioned above, in which the diets consisted practically of fat-free substances, namely, starches and konnyaku. The quantity of ether extract, 0.5 to 0.6 gram, in the feces in these experiments may reasonably be considered as derived from metabolic products. In the experiments with barley the amount of ether extract in the feces was considerably in excess of that in the food. Assuming that all of the ether extract in the barley was undigested, there was still an excess of nearly 4 grams per day in each case in the feces, or nearly seven to eight times as much ether extract in the barley feces than in feces from macaroni or vermicelli. The dry material of the barley contained 2 to 4 per cent fiber, and, moreover, the grains when eaten were not in finely pulverized condition. Indeed, in some cases the whole grain was used, being prepared for the table simply by boiling. The coarse nature of such food very probably caused considerable mechanical stimulation of the action of the intestine and possibly a corresponding increase in the secretion of digestive juices and a consequent increase in the amount of metabolic products excreted.

In the feces from diets consisting very largely of starches—macaroni, vermicelli, and the like—0.5 to 0.9 gram of ether extract per day was found. This probably represents the usual amount of ether extract of metabolic products in the feces pertaining to diets of such character.

CORRECTIONS FOR METABOLIC PRODUCTS IN FECES.

It appears, then, that about 0.3 to 0.9 gram nitrogen and 0.5 to 0.9 gram of ether extract per day in the feces is derived from metabolic products. These values are of course not absolute, but must undoubtedly vary with the subject, and especially, as has been shown, with the kind and amount of food eaten. They do, however, afford the means for judging the accuracy of the coefficients of digestibility obtained in digestion experiments and at the same time afford valuable suggestions for conducting such experiments and interpreting results. For example, when the amounts of protein and fat in the foods studied are small, the error involved in the computations of the coefficients of digestibility for these nutrients may be relatively so large, because of the presence of metabolic products in feces, that the results of the experiments are of little value. On the other hand, the larger the amount of these nutrients in the food the smaller will be the proportionate error involved.

This may be illustrated in an excellent manner by the results of digestion experiments Nos. 9, 10, and 11 of the present compila-

tion. In these experiments the amounts of fat furnished by the different kinds of fish in the diets varied widely. The following table shows the amount of fat (ether extract) in the food and in the feces, and the coefficient of digestibility as actually calculated from the results of the experiments and as estimated by assuming that 0.8 gram of ether extract in the feces was due to metabolic products.

TABLE 103.—*Digestibility of fat in experiments with fish; determined and corrected values.*

Experiment No.	Kind of fish.	Fat per day.		Digestibility of fat.		
		In food.	In feces.	Found.	Estimated.	Difference.
		Grams.	Grams.	Per cent.	Per cent.	Per cent.
9	Porgy.....	5.0	1.3	73.2	90.0	16.8
11	Herring.....	14.3	2.8	80.2	86.0	5.8
10	Salmon.....	38.5	2.4	93.8	95.8	2.0

It will be seen from the figures given above that the differences between the coefficients of digestibility as actually found and as estimated varied almost inversely in proportion to the amount of fat in the food. In experiment No. 11 the amount of fat in the food was 2.9 times that in experiment No. 9, and the difference between the found and estimated coefficient of digestibility in the former experiment is just 2.9 times that in the latter. There is a similar relation between the results of experiments Nos. 9 and 10.

Although the estimated coefficients of digestibility are not decisive, they afford valuable help in judging of the comparative digestibility of two different kinds of food from values found by actual experiments in which the amounts of the nutrients in the different foods are variable.

On the other hand, if the amounts of nutrients from different foods are approximately equal the results actually obtained are fairly comparable. This may be illustrated by the results obtained for protein in experiments Nos. 4, 5, and 79, summarized in Table 104. The estimated digestibility of protein was obtained on the assumption that 0.5 gram of nitrogen or 3.1 grams of protein in the feces was due to metabolic products.

TABLE 104.—*Digestibility of protein in vegetable foods; determined and corrected values.*

Experiment No.	Kind of food.	Protein per day.		Digestibility of protein.		
		In food.	In feces.	Found.	Estimated.	Difference.
		Grams.	Grams.	Per cent.	Per cent.	Per cent.
4	Rice.....	50.3	11.2	79.1	83.8	4.7
5	do.....	50.0	9.5	81.2	87.2	6.0
79	Vermicelli.....	49.0	5.4	89.0	95.3	6.3

It will be seen from the figures in the table that the differences between the coefficients of digestibility as found by actual experiments and as estimated vary somewhat, but that the results obtained in the different experiments are fairly comparable with one another.

**DIGESTIBILITY OF THE NUTRIENTS OF DIFFERENT CLASSES OF
FOOD MATERIALS IN JAPANESE MIXED DIET.**

The data summarized in the foregoing pages are of two kinds—those obtained in 54 experiments in which the diets consisted practically of single food materials, either vegetable or animal, and those from 74 experiments with more varied diets, consisting either of several kinds of vegetable foods or of both vegetable and animal foods. An important question to be considered is, What is the digestibility of the nutrients of different classes of food materials when these are eaten together in mixed diet?

This question can not be decided from the results of the experiments with different food materials eaten singly, because it has been often observed that when any food material is eaten alone the coefficients of digestibility of its nutrients are not always the same as when the same food is combined with other foods. For example, in experiments with rice the nutrients of rice were digested more thoroughly when eaten with fish or with tofu than when rice alone was eaten. The coefficients of digestibility obtained by digestion experiments on single food materials may or may not be applied to the same food materials when they are eaten in the usual manner as components of an ordinary mixed diet. On the other hand, the coefficients obtained by digestion experiments with mixed diet refer directly to the total nutrients of the diet, but not necessarily to the nutrients of the separate food materials included in the diet.

The estimation of the digestibility of the nutrients of any given food material or group of food materials of similar character when used in mixed diet is very largely a matter of assumption. The method commonly followed is to adopt certain coefficients from the results of experiments with single food materials and to test their accuracy by applying them in the case of mixed diets in which these food materials were used, and to compare the digestibility of the nutrients of the mixed diet as a whole as computed by the use of such figures for digestibility of the individual articles with the results of actual experiment with total diet, increasing or decreasing the coefficients for the separate items as seems necessary from a comparison of the calculated results with those actually found. As a result of such computations from the data of digestion experiments included in the present compilation the factors given in the

following table have been obtained and may be considered to represent the coefficients of digestibility of nutrients of different food materials in the Japanese diet:

TABLE 105.—Average coefficients of digestibility of nutrients of different groups of food materials and of total nutrients of Japanese mixed diet.

Kind of food.	Protein.	Fat.	Carbo- hydrates.
<i>Mixed vegetable and animal diet.</i>			
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Animal foods.....	97	87	98
Cereals, barley not included.....	81	82	98
Legumes and their preparations.....	^a 78	82	95
Sugars and starches.....			98
Vegetables.....	75	82	93
Vegetable foods.....	80	82	98
Total food.....	87	^b 85	98
Total food with barley.....	76	85	97
<i>Vegetable mixed diet.</i>			
Cereals.....	79	82	98
Legumes and their preparations.....	75	82	95
Sugars and starches.....			98
Vegetables.....	73	82	93
Total food.....	78	82	98
Total food with barley.....	76	82	97

^a This coefficient proposed for the protein of both the legumes themselves and the various preparations from them, though at least approximately correct for the former, would appear to be too low for the latter when the high digestibility of tofu noted in the experiments is considered. There are, however, no experimental data regarding the digestibility of protein in miso and shoyu. It is probably higher than that of the protein of the legumes themselves, but on the other hand a considerable part of the protein in these preparations is in nonprotein form, by which its actual nutritive value would be lessened; and so these two opposing factors may counterbalance each other to a certain extent. Owing to the lack of data it has, therefore, been assumed that the coefficient of digestibility of protein found for the legumes themselves would be applicable also to the preparations from them.

^b The assumed digestibility of fat in the Japanese diet is low in comparison with the corresponding factor for fat in the American diet, which is 95 per cent. (See Connecticut (Storrs) Expt. Sta. Rpt. 1899, p. 86.) There are, in fact, a few experiments in which the digestibility of fat is comparable with the American coefficient, two of which were made with tofu and three with tofu and rice. In these experiments, however, the amounts of fat eaten were 3 to 6 times as large as in the ordinary Japanese diet. The average amount of fat in all ordinary mixed Japanese diets is scarcely 20 grams, and in the experiment with vegetable mixed diet the average amount is but 11 grams. Fat, therefore, is not an important nutrient in the Japanese dietary, and the apparent low digestibility found in actual experiments is to be accounted for at least in part by the large amount of ether extract in the metabolic products of the feces as compared with the small amount in the food.

To test the accuracy of the coefficients given in the table above, the factors have been applied to the data of actual digestion experiments with mixed diets in the following manner: The amount of digestible protein, for example, was calculated on the assumption that 97 per cent of the protein in actual food, 81 per cent of that in cereals, 78 per cent of that in legumes and their preparations, and 75 per cent of that in vegetables would be digested. The sum of the amounts of protein thus computed for the different groups, divided by the total amount of protein in the food eaten and multiplied by 100, would give the calculated coefficient of digestibility of protein of the total diet. Similar computations were made for the other nutrients.

The following table shows the results of such computations for the digestibility of protein in the mixed diet as compared with the results of

actual digestion experiments for which such computations were made. For the purposes of the above comparison the only experiments selected were those in which the amounts of nutrients in the different groups of food materials were known. Thirteen digestion experiments with mixed vegetable and animal diet and an equal number with vegetable mixed diet were thus selected for the comparison of digestibility of protein. In very many cases it was not possible to calculate the nutrients in different groups of food, as the composition of the diet was calculated from the results of analyses of composite samples.

TABLE 106.—*Comparison of coefficients of digestibility as found by actual experiments and as calculated by the proposed factors for digestibility of protein.*

Experiment No.	Kind of food.	Found.	Calculated.	Experiment No.	Kind of food.	Found.	Calculated.
20	Mixed animal and vegetable diet.....	<i>Per cent.</i> 84.5	<i>Per cent.</i> 87.7	22	Mixed vegetable diet.....	<i>Per cent.</i> 76.5	<i>Per cent.</i> 78.0
21	do.....	80.6	84.6	23	do.....	76.8	77.9
25	do.....	90.2	86.3	24	do.....	80.7	78.3
26	do.....	80.4	83.4	33	do.....	77.2	77.8
27	do.....	84.3	85.2	34	do.....	77.3	77.5
28	do.....	87.1	87.2	35	do.....	^a 68.3	^a 77.7
29	do.....	88.3	87.9	36	do.....	77.6	77.6
30	do.....	88.0	86.4	38	do.....	77.7	78.6
31	do.....	85.9	85.5	39	do.....	82.2	78.0
72	do.....	85.5	85.2	40	do.....	79.2	78.5
120	do.....	91.9	92.8	41	do.....	80.0	78.4
121	do.....	93.1	94.3	42	do.....	81.6	78.6
122	do.....	93.5	93.7	43	do.....	76.9	78.6
	Average 13 experiments.....	87.2	87.7		Average 12 experiments.....	78.6	78.1

^a Not included in average.

It appears that the variations between the coefficients for protein, as actually found from the results of the experiments and as calculated by the factors given above, are in the main not very great. In some individual experiments the differences were as high as 4 per cent and in others they were merely nominal. In some cases the calculated values are higher and in others lower than those found by experiments. Of course slight variations in individual experiments are inevitable. Different specimens of a given food material may differ in digestibility, with the usual differences in composition and in methods of cooking. Furthermore, different individuals who have served as subjects of experiments undoubtedly vary in their capacity for digesting the same kind of food. It is interesting to observe, however, that when the averages are considered the coefficients as calculated and as actually found agree within one-half of 1 per cent.

As has already been explained, very few of the digestion experiments give satisfactory results regarding the digestibility of fat.

On the other hand there are more than 20 of the digestion experiments with ordinary mixed diet in which the digestibility of the total nitrogen-free organic substances, including both fat and carbohydrates, could be calculated. To test the accuracy of the assumed coefficients for digestibility of fat and carbohydrates, these factors were applied to the results of actual digestion experiments above mentioned. The following table shows the comparison of the coefficients as calculated and as found by actual experiment:

TABLE 107.—*Comparison of coefficients of digestibility of nitrogen-free organic substances as found by actual experiments and as calculated by the proposed factors for fat and carbohydrates in mixed diet.*

Experiment No.	Kind of food.	Nitrogen free organic substance.	
		Found.	Calculated.
		<i>Per cent.</i>	<i>Per cent.</i>
51	Rice, meat, fish, and vegetables	98.2	97.6
52	do.....	98.6	97.7
53	do.....	98.2	97.7
54	do.....	98.8	97.7
55	do.....	99.1	97.5
56	do.....	98.6	97.7
57	Rice, barley, meats, fish, and vegetables	96.8	96.7
58	do.....	96.5	96.7
59	do.....	96.6	96.7
60	do.....	96.7	96.7
61	do.....	96.8	96.7
62	do.....	96.5	96.7
64	Rice, bread, meats, fish, and vegetables	96.3	97.1
65	do.....	97.0	97.4
66	do.....	97.2	97.7
67	do.....	96.9	97.4
68	do.....	96.9	97.4
69	do.....	96.6	97.5
70	Rice, meats, and vegetables	96.9	97.6
71	Bread, meats, and vegetables	96.5	96.6
Average 20 experiments		97.3	97.2

In applying the assumed coefficients to the results of actual experiments it was necessary to consider only the figures for total nutrients, since in all of these experiments referred to the sample of food analyzed was that of a composite of the food actually eaten, and the data of the experiments did not afford means for determining the amounts of the nutrients derived from different groups of food materials in the diet. The close agreement of the values, as calculated with those actually found by experiment, would seem to indicate that so far as the total nutrients in the ordinary Japanese mixed diet are concerned, the assumed coefficients for fat and carbohydrates are not far from the truth.

Another test of these assumed factors was made in the following manner. The proportions of nutrients furnished by different groups of food materials in the average ordinary mixed diet, as given in Table 110, were multiplied by the assumed factors for the particular

nutrients of different groups of food, and the sum of the products was divided by 100. For example—

Animal food supplied 38 per cent of total protein; then..	$38 \times 97 = 3,686.0$
Cereals supplied 47.5 per cent of total protein; then....	$47.5 \times 81 = 3,847.5$
Legumes supplied 8 per cent of total protein; then	$8 \times 78 = 624.0$
Vegetables supplied 6.5 per cent of total protein; then .	$6.5 \times 75 = 487.5$
Total.....	8,645.0

The sum of these products divided by 100 gives the calculated coefficients for protein in the total food of mixed diet. In the same manner the sum of the products for cereals, legumes, and vegetables divided by 62 would give the calculated coefficient for protein in vegetable food of mixed diet. Similar calculations may be made for fats and carbohydrates.

The close agreement between the assumed factors and the calculated results is rather surprising. The proportions of nutrients furnished by different groups of food materials in the diet of the digestion experiments upon the results of which the assumed factors were based, and those in the average mixed diet from which the proportions of nutrients used in these calculations were obtained, must naturally have been different. Taking all this into consideration, it seems that these assumed coefficients can reasonably be applied to the data of ordinary Japanese mixed diet for the calculations of the digestibility of the nutrients of the diet, and this has been done in the case of dietary studies included in this compilation. It is especially emphasized, however, that these factors are at best merely tentative, based upon the most reliable available data, and are subject to change as more information accumulates.

EXPERIMENTS ON THE METABOLISM OF NITROGEN.

Reference has previously been made to the fact that in connection with many of the investigations on the amounts of food consumed and the digestibility of the nutrients of food materials, the urine was collected and analyzed and the balance between the income and outgo of nitrogen was ascertained. The data of these determinations of the metabolism of nitrogen are summarized in this section. A list of these experiments is given in Table 108.

TABLE 108.—*List of nitrogen metabolism experiments.*

Serial No.	Date of publication.	Observer.	Subject.	Duration (days).	Food.	Accompanying dietary and digestion experiments.
1	1887	Osawa and Ueda.	Laboratory assistant.	4	Barley.	Digestion experiment No. 1.
2	1887		do.	4	do.	Digestion experiment No. 2.
3	1887		do.	3	do.	Digestion experiment No. 3.
4	1887		do.	3	Rice.	Digestion experiment No. 4.
5	1887	do.	do.	3	do.	Digestion experiment No. 5.
6	1887		do.	3	Beans, dried.	Digestion experiment No. 6.
7	1887		do.	3	do.	Digestion experiment No. 7.
8	1887		do.	2	Tofu.	Digestion experiment No. 8.
9	1887	do.	Laboratory assistant.	3	Porky.	Digestion experiment No. 9.
10	1887		do.	3	do.	Digestion experiment No. 10.
11	1887		do.	3	Herring, dried.	Digestion experiment No. 11.
12	1887		do.	3	Cod, dried.	Digestion experiment No. 12.
13	1887	Kellner and Y. Mori.	Chemist.	3	Rice, meat, milk, and vegetables.	Dietary study No. 9 and digestion experiment No. 13.
14	1887		do.	3	Rice, fish, and vegetables.	Dietary study No. 20 and digestion experiment No. 14.
15	1887		do.	3	Rice, barley, and vegetables.	Dietary study No. 21 and digestion experiment No. 15.
16	1888		do.	3	Rice and tofu.	Digestion experiment No. 16.
17	1888	Suchi.	Observer.	6	Rice, tofu, and oil.	Digestion experiment No. 17.
18	1889	Osawa.	Medical student.	13	Rice and tofu.	Digestion experiment No. 18.
19	1889	Tsuboi.	Man.	3	Glutinous rice.	Digestion experiment No. 19.
20	1889	Kumagawa.	Observer.	5	Rice, meat, fish, and vegetables.	Dietary study No. 27 and digestion experiment No. 20.
21	1889		do.	5	Rice, fish, and vegetables.	Dietary study No. 28 and digestion experiment No. 21.
22	1889		do.	5	Rice and vegetables.	Dietary study No. 29 and digestion experiment No. 22.
23	1889		do.	3	do.	Dietary study No. 30 and digestion experiment No. 23.
24	1890	Nakasawa.	do.	3	do.	Digestion experiment No. 24.
25	1890	Tanboi and Murata.	Physician.	3	Rice, meat, fish, and vegetables.	Dietary study No. 31 and digestion experiment No. 25.
26	1890		Laboratory assistant.	3	do.	Dietary study No. 32 and digestion experiment No. 26.
27	1890		do.	3	do.	Dietary study No. 33 and digestion experiment No. 27.
28	1891		Medical student.	10	do.	Dietary study No. 35 and digestion experiment No. 28.
29	1891	Amaya and Kirisawa.	Laboratory assistant.	7	do.	Dietary study No. 36 and digestion experiment No. 29.
30	1891		Physician.	7	do.	Dietary study No. 37 and digestion experiment No. 30.
31	1891		Laboratory assistant.	6	Rice, fish, and vegetables.	Dietary study No. 37 A and digestion experiment No. 31.
32	1891		do.	10	do.	Dietary study No. 38 and digestion experiment No. 32.
33	1892	do.	do.	5	Rice, beans, and vegetables.	Dietary study No. 38 and digestion experiment No. 32.
34	1892	do.	do.	7	Rice and vegetables.	Dietary study No. 39 and digestion experiment No. 33.
35	1892	do.	do.	6	do.	Dietary study No. 40 and digestion experiment No. 34.
36	1892	do.	do.	6	do.	Dietary study No. 41 and digestion experiment No. 35.
37	1892	Taniguchi.	Physician.	2	do.	Dietary study No. 42 and digestion experiment No. 36.
38	1892		do.	4	Rice and beef extract.	Dietary study No. 42 and digestion experiment No. 36.
39	1892		Laboratory servant.	2	Rice and pickled radish.	Dietary study No. 59 and digestion experiment No. 37.
40	1892		do.	2	do.	Dietary study No. 60 and digestion experiment No. 38.
41	1892	do.	do.	10	Rice and miso.	Dietary study No. 61 and digestion experiment No. 39.
42	1892	do.	do.	10	Rice and vegetables.	Dietary study No. 61 and digestion experiment No. 40.
43	1892	do.	do.	10	do.	Dietary study No. 62 and digestion experiment No. 41.
44	1892	Ol.	Military nurse.	5	Dietary study No. 63 and digestion experiment No. 42.	Dietary study No. 63 and digestion experiment No. 42.
				3	Rice and fish.	Dietary study No. 64 and digestion experiment No. 43.
				3	do.	Dietary study No. 65 and digestion experiment No. 44.

45	1892	do.	do.	3	Rice and tofu.	Dietary study No. 68 and digestion experiment No. 45.
46	1892	do.	do.	3	Rice and vegetables.	Dietary study No. 69 and digestion experiment No. 46.
47	1892	do.	do.	3	Rice, barley, and meat.	Dietary study No. 70 and digestion experiment No. 47.
48	1892	do.	do.	3	Rice, barley, and fish.	Dietary study No. 71 and digestion experiment No. 48.
49	1892	do.	do.	3	Rice, barley, and tofu.	Dietary study No. 72 and digestion experiment No. 49.
50	1892	do.	do.	3	Rice, barley, and vegetables.	Dietary study No. 73 and digestion experiment No. 50.
51	1892	Mori, Oi, and Iishima.	Soldier.	8	Army rice ration.	Dietary study No. 74 and digestion experiment No. 51.
52	1892	do.	do.	8	do.	Dietary study No. 75 and digestion experiment No. 52.
53	1892	do.	do.	8	do.	Dietary study No. 76 and digestion experiment No. 53.
54	1892	do.	do.	8	do.	Dietary study No. 77 and digestion experiment No. 54.
55	1892	do.	do.	8	do.	Dietary study No. 78 and digestion experiment No. 55.
56	1892	do.	do.	8	do.	Dietary study No. 79 and digestion experiment No. 56.
57	1892	do.	do.	8	Army rice and barley ration.	Dietary study No. 80 and digestion experiment No. 57.
58	1892	do.	do.	8	do.	Dietary study No. 81 and digestion experiment No. 58.
59	1892	do.	do.	8	do.	Dietary study No. 82 and digestion experiment No. 59.
60	1892	do.	do.	8	do.	Dietary study No. 83 and digestion experiment No. 60.
61	1892	do.	do.	8	do.	Dietary study No. 84 and digestion experiment No. 61.
62	1892	do.	do.	8	do.	Dietary study No. 85 and digestion experiment No. 62.
63	1892	do.	Military nurse.	8	Army barley ration.	Dietary study No. 86 and digestion experiment No. 63.
64	1892	do.	Soldier.	8	Army bread ration.	Dietary study No. 87 and digestion experiment No. 64.
65	1892	do.	do.	8	do.	Dietary study No. 88 and digestion experiment No. 65.
66	1892	do.	do.	8	do.	Dietary study No. 89 and digestion experiment No. 66.
67	1892	do.	do.	8	do.	Dietary study No. 90 and digestion experiment No. 67.
68	1892	do.	do.	8	do.	Dietary study No. 91 and digestion experiment No. 68.
69	1892	do.	do.	8	do.	Dietary study No. 92 and digestion experiment No. 69.
70	1892	Oi.	Military nurse.	12	Army rice ration.	Dietary study No. 93 and digestion experiment No. 70.
71	1892	do.	do.	12	Army bread ration.	Dietary study No. 94 and digestion experiment No. 71.

The experiments are numbered in the above list in the order of publication. There were 71 in all, published between the years 1887 and 1892, inclusive. The subjects were all men, mostly of the professional and military classes. There was one subject in each experiment except Nos. 44-50 and 70-71, in which the results for several subjects were combined. The experimental periods varied from 2 to 13 days. In 12 experiments only one kind of food material was used; in the remainder the diet included two or more kinds of food. In every case the determinations were made in connection with studies of the digestibility of the food, the corresponding digestion experiments being indicated in the last column of the list above.

The method was that generally followed in such experiments. The analyses of the food and feces in connection with the digestion experiment gave the data regarding the quantities of nitrogen in these materials. Urine was collected each day during the experimental period, and the nitrogen in it determined, usually by the Kjeldahl method, though in some of the earlier investigations Liebig's method was employed to determine the amount of urea, and from this the amount of nitrogen was calculated.

The data of the experiments are given in the following table, which includes three groups of experiments, namely, (1) those in which the determinations were made in connection with digestion experiments with single food materials; (2) those in which the data were obtained in connection with special investigations with mixed diets; and (3) experiments made in connection with studies undertaken to ascertain the daily protein requirement.

TABLE 109.—Summary of nitrogen metabolism experiments.

Serial No.	Observer.	Subject.			Duration.	Food per day.			Fuel value.	Nitrogen per day.			Gain (+) or loss (-).
		Occupation.	Age.	Weight.		Kind.	Protein (N×0.25).	In food. ^a		In urine.	In feces.		
<i>Experiments with single foods.</i>													
1	Osawa and Ueda.	Laboratory assistant.	23	53.0	4	Barley	Grams. 52.6	Calorics. 1,520	Grams. 8.4	Grams. 10.0	Grams. 5.0	Grams. -7.5	
2	do.	do.	23	53.0	4	do.	47.7	b 1,535	c 7.6	12.6	3.7	-8.7	
3	do.	do.	23	53.0	4	do.	40.6	b 1,350	a 6.5	14.9	3.4	-11.8	
4	do.	do.	23	53.0	3	Rice.	53.1	2,625	e 8.5	9.3	1.8	-2.6	
5	do.	do.	23	53.0	3	do.	60.6	2,665	f 8.1	9.9	1.5	-3.3	
6	do.	Medical student.	23	53.0	3	Beans, dried.	141.3	1,210	g 22.6	17.3	8.6	-3.3	
7	do.	do.	23	53.0	3	do.	84.2	885	A 13.5	11.3	4.2	-2.0	
8	do.	do.	23	53.0	2	Tofu.	230.0	2,040	f 36.8	33.2	1.5	+2.1	
9	do.	Laboratory assistant.	23	53.0	3	Porky.	235.1	1,045	k 37.6	35.5	.9	+1.2	
10	do.	do.	23	53.0	3	Salmon.	233.1	1,605	l 46.9	41.8	.9	+4.2	
11	do.	do.	23	53.0	3	Herring, dried.	238.7	1,425	m 38.2	34.9	2.7	+ .6	
12	do.	do.	23	53.0	3	Cod, dried.	233.8	b 1,265	n 37.4	38.2	1.8	-2.6	
19	Tsuboi.	Not stated.	49.0	49.0	2	Glutinous rice cake—mochi.	91.9	c 3,540	o 14.7	8.4	5.1	+1.2	
<i>Experiments with mixed diets.</i>													
13	Kellner and Mori.	Chemist.	23	52.0	3	Rice, meat, milk, and vegetables.	123.0	2,375	19.7	18.6	1.2	.1	
14	do.	do.	23	52.0	3	Rice, fish, and vegetables.	109.3	2,515	17.5	14.4	2.2	+ .9	
15	do.	do.	23	52.0	3	Rice, barley, and vegetables.	70.9	2,010	11.3	9.8	2.8	+1.3	
16	Suchi.	Observer.	21	52.0	7	Rice and tofu.	166.3	2,860	26.6	25.0	1.3	+1.3	
17	do.	do.	21	40.0	6	Rice, tofu, and vegetable oil.	166.3	3,445	26.6	23.9	1.5	+1.2	
18	Osawa.	Medical student.	25	40.0	9	Rice and tofu.	86.3	1,590	13.8	13.2	.6	.....	
24	Nakasawa.	Observer.	25	46.0	3	Rice and vegetables.	65.0	p 1,865	10.4	8.0	2.0	+ .4	
25	Tsuboi and Murata.	Physician.	40.2	40.2	3	Rice, meat, fish, and vegetables.	53.5	2,200	8.5	9.0	.8	.9	
26	do.	Laboratory assistant.	40.4	40.4	3	do.	57.8	2,430	8.1	7.8	1.6	1.3	
27	do.	Medical student.	51.1	51.1	3	do.	30.8	2,165	9.3	9.1	1.5	1.3	
36	Taniguchi.	Laboratory servant.	44.0	44.0	2	Rice and beef extract.	69.4	2,735	11.1	8.5	.9	+1.7	
38	do.	do.	44.0	44.0	4	Rice and pickled radish.	64.6	2,740	10.3	8.8	2.3	.8	
39	do.	do.	44.0	44.0	10	Rice and miso.	80.9	3,020	12.9	7.3	2.3	+3.3	
40	do.	do.	44.0	44.0	10	Rice and vegetables.	60.1	2,530	9.6	9.2	2.0	1.6	
41	do.	do.	44.0	44.0	10	do.	65.8	2,740	10.5	8.4	2.1	.....	

^a In experiments Nos. 2-12 the ingredients of shoyu used as food adjunct were not taken into account in determining digestibility (see p. 146). The nitrogen, however, should be included here. If the shoyu contained 1.35 per cent. nitrogen there should be added to the total nitrogen in food and to gain or loss of nitrogen, the following: c 0.6 gram; d 0.8 gram; e 0.4 gram; f 0.1 gram; g 0.8 gram; h 0.2 gram; i 0.1 gram; k 0.2 gram; l 0.1 gram; m 0.8 gram; n 0.9 gram.

^b In these experiments the amount of fat in the feces was greater than that in the food (see pp. 140-151), and in calculating fuel value the fat was ignored.

^c The fuel value was calculated from the digestible nutrients of mochi alone (see p. 155).

^d The fat was ignored in calculating fuel value here. The amount of fat in feces was greater than in the food consumed. See the corresponding digestion experiment No. 24, on p. 158.

TABLE 109.—Summary of nitrogen metabolism experiments—Continued.

Serial No.	Observer.	Subject.			Duration.	Food per day.		Nitrogen per day.				Gain (+) or loss (-).
		Occupation.	Age.	Weight.		Kind.	Protein (N×6.25).	Fuel value.	In food.	In urine.	In feces.	
				Kilos.	Days.	Experiments with mixed diets— (Continued.)						
42	Taniguchi.	Laboratory servant.		44.0	10	Rice and vegetables.	Grams. 64.7	Calories. 2,730	Grams. 10.3	Grams. 7.2	Grams. 1.9	+ 1.2
43	do.	do.		44.0	5	do.	65.0	2,745	10.4	7.5	2.4	+ 2.5
44	Oi.	Military nurse.			3	Rice and fish.	127.9	3,395	20.5	17.7	4.4	+ 2.9
45	do.	do.			3	Rice and tofu.	75.1	2,795	12.0	12.8	.1	- 3.1
46	do.	do.			3	Rice and vegetables.	50.0	2,940	8.0	11.0		+ 4.1
47	do.	do.			3	Rice, barley, and meat.	135.2	3,465	21.7	16.4	1.2	+ 4.8
48	do.	do.			3	Rice, barley, and fish.	139.5	3,330	22.3	16.1	1.4	+ 4.3
49	do.	do.			3	Rice, barley, and tofu.	86.7	2,720	13.9	12.2	1.4	+ 2.7
50	do.	do.			3	Rice, barley, and vegetables.	61.9	2,915	9.9	14.1	2.2	+ 4.3
51	Mori, Oi, and Ii-shima.	Soldier.	24	54.7	8	Army, rice ration.	88.0	2,515	14.1	9.2	2.2	+ 2.7
52	do.	do.		55.2	8	do.	87.4	2,715	14.0	8.5	2.0	+ 3.5
53	do.	do.	24	66.7	8	do.	89.8	2,825	14.4	10.4	2.3	+ 1.7
54	do.	do.	24	59.7	8	do.	86.7	2,710	13.9	9.2	2.6	+ 2.1
55	do.	do.	23	56.8	8	do.	84.2	2,730	13.5	9.2	2.3	+ 2.0
56	do.	do.	24	56.3	8	do.	73.8	2,345	11.8	8.1	3.2	+ 1.6
57	do.	do.	23	56.5	8	Army, rice-barley ration.	74.0	2,225	11.8	9.0	3.2	- 1.4
58	do.	do.	22	61.0	8	do.	79.8	2,330	12.8	10.9	3.3	- 1.3
59	do.	do.	22	61.7	8	do.	78.9	2,285	12.6	9.7	3.2	- 1.8
60	do.	do.	22	57.5	8	do.	78.0	2,255	12.5	9.5	4.8	- 1.8
61	do.	do.	22	59.5	8	do.	78.3	2,265	12.5	9.5	3.1	- 3.5
62	do.	do.	22	56.7	8	do.	79.9	2,295	12.8	10.0	4.1	- 1.3
63	do.	Military nurse.	46	52.2	8	Army, barley rations.	68.3	1,370	10.9	9.7	4.3	- 3.1
64	do.	Soldier.	24	57.8	8	Army, bread ration.	80.0	2,250	12.8	13.2	2.7	- 2.3
65	do.	do.	24	61.7	8	do.	79.4	2,240	12.7	12.3	2.7	- 3.5
66	do.	do.	24	60.9	8	do.	78.4	2,270	12.5	13.8	2.2	- 2.8
67	do.	do.	24	58.0	8	do.	78.7	2,245	12.6	14.7	1.9	- 4.0
68	do.	do.	23	60.2	8	do.	78.5	2,255	12.6	12.4	2.2	- 2.2
69	do.	do.	24	54.6	8	do.	77.4	2,230	12.4	12.4	2.2	- 4.4
70	Oi.	Military nurse.			12	Army, rice ration.	84.7	3,065	13.6	12.8	4.4	+ 1.0
71	do.	do.			12	Army, bread ration.	113.0	2,790	18.1	16.6	.5	
						Experiments made to test protein requirement.						
20	Kumagawa.	Observer.	27	48.4	13	Rice, meat, fish, vegetables, and beer.	90.3	2,470	14.5	12.1	2.3	+ .1
21	do.	do.	27	48.3	5	Rice, fish, vegetables, and beer.	58.0	2,045	9.3	8.7	1.8	- 1.2
22	do.	do.	27	48.4	5	Rice, fish, vegetables, and beer.	44.2	1,980	7.1	7.1	1.7	- 1.7

23	do.....	27	48.7	9	do.....	54.7	2,555	8.8	6.1	2.0	+	.7
28	Amaya and Kiri- sawa.	20	43.0	10	Rice, meat, fish, and vegetables...	53.5	2,060	13.4	11.0	1.7	+	.7
29	do.....	.....	.....	7	do.....	79.0	2,220	12.6	10.2	1.5	+	.9
30	do.....	Amaya (observer)	42.9	6	Rice, salted fish, and vegetables...	73.2	2,030	11.7	9.9	1.4	+	.4
31	do.....	Kirisawa (observer)	43.0	6	do.....	73.2	2,180	11.7	8.9	1.7	+	.1
32	do.....	do.....	42.8	10	Rice, beans, and vegetables...	82.8	2,305	13.3	10.0	2.3	+	1.0
33	do.....	do.....	43.6	5	Rice and vegetables...	47.6	1,825	7.6	7.4	1.7	-	1.5
34	do.....	do.....	42.3	7	do.....	52.4	2,200	8.4	6.0	1.9	+	.5
35	do.....	Amaya (observer)	49.6	6	Rice and vegetables...	50.3	2,120	8.1	6.4	2.6	-	.9
36	do.....	do.....	49.7	6	do.....	56.0	2,375	8.9	6.6	2.0	+	.3

The amount of nitrogen obtained in the daily food was small in many of the experiments; in others the quantities were directly comparable with those found in the average American diet. In some of the experiments there were gains of nitrogen and in others losses. In general, gains were more commonly noted when the diet furnished fairly large amounts of nitrogen. Final deductions regarding nitrogen requirements can not be drawn from these experiments, for they were, of course, not made under uniform conditions, nor were they carried on as a whole with reference to providing an answer to this question.

FUEL VALUE OF NUTRIENTS IN JAPANESE DIET.

An important function of food is to supply the body with energy for the performance of internal and external muscular work and the maintenance of body temperature. It is therefore at least as desirable to know how much energy the food will supply as to determine how much of a given nutrient it furnishes.

Since different forms of energy may be transformed into heat, and since most of the energy supplied to the body is eventually thus transformed and given off as heat, a convenient measure of the energy value of food is the quantity of heat it will generate upon complete oxidation. Energy values of food are therefore commonly determined by burning samples of the food in an apparatus by which the quantity of heat generated may be measured, and the results, called "heats of combustion," are expressed in units of heat, i. e., calories, a calorie being the quantity of heat that will raise the temperature of 1 kilogram of water 1° C.

The total potential energy of a given quantity of food eaten, however, is greater than that which the body will derive from it, because, in the first place, not all the food eaten is actually digested and utilized by the body, and, in the second place, the body is not capable of oxidizing completely one of the nutrients, namely, the protein. To determine the net energy value of the food, or, as it is generally called, the "fuel value," it is necessary to allow for the energy thus not utilized. In accurate investigations the fuel value of food is ascertained from actual determinations of the heats of combustion of the food eaten, of the material not digested and utilized, which is excreted in the feces, and of the incompletely oxidized products from protein, which are eliminated in the urine.

In ordinary dietary studies the fuel value of the diet is commonly estimated from the quantities of nutrients in the diet by means of factors representing the fuel values of the nutrients. In 1885, Rubner^a proposed the following factors for the fuel values of nutrients in ordinary mixed diet: Protein and carbohydrates, 4.1 calories per gram,

^a *Ztschr. Biol.*, 21 (1885), p. 377

and fat, 9.3 calories per gram. These factors were based upon the best data then available, chiefly from German research, and have been very extensively used. More recently, in 1899, Atwater and Bryant^a have considered the question, and, taking also into account the large amount of experimental research, the majority of it American, that has accumulated since Rubner's factors were deduced, have derived the following factors: 4.0 calories per gram for protein and carbohydrates, and 8.9 calories per gram for fat, in a mixed diet. These factors they consider to be fairly accurate for the fuel values of the nutrients of an ordinary mixed diet, at least such a diet as is common in America.

As has been stated, in none of the Japanese investigations were the heats of combustion actually determined. In a few of the dietary studies the fuel values of the diets were calculated by use of Rubner's factors, but in many cases they were not considered. A knowledge of the fuel value of the diet, however, is very desirable. It seems reasonably certain, in view of the differences between either the German or the American and the Japanese diet in respect to the proportions of animal and vegetable foods consumed, and the consequent differences in digestibility of the nutrients, especially protein, that neither of the above-mentioned sets of factors is applicable for such calculations. The compiler has therefore undertaken to deduce factors which he believes to be more applicable, and, as previously explained (p. 17), has used them in computing the fuel values included in the tables of investigations here compiled. These factors are summarized in Table 110, together with the data necessary for the estimation of the factors. Explanation of the method of computing the factors follows the table.

^a Connecticut Storrs Station Rpt. 1899, p. 73.

TABLE 110.—*Proposed factors for heats of combustion and fuel values of nutrients in different groups of food materials in Japanese ordinary mixed diet and in vegetable mixed diet.*

Kind of food material.	Proportion of total nutrients furnished by each group.	Heat of combustion per gram.	Proportion of total nutrients actually digestible.	Fuel value.	
	A.	B.	C.	Per gram digestible nutrients.	Per gram total nutrients.
				D. ^a	E (=D×C).
<i>Protein.</i>					
Animal food.....	Per cent. 38.0	Calories. 5.65	Per cent. 97	Calories. 4.40	Calories. 4.27
Cereals.....	47.5	5.80	81	4.55	3.69
Legumes and their preparations.....	8.0	5.70	78	4.45	3.47
Vegetables.....	6.5	5.00	75	3.75	2.81
Vegetable food.....	62.0	5.70	80	4.45	3.56
Total food (ordinary mixed diet).....	100.0	5.70	87	4.45	3.87
Total food (ordinary mixed diet with barley).....	100.0	5.70	76	4.45	3.38
Total food (vegetable mixed diet).....	100.0	5.70	78	4.45	3.47
<i>Fat.</i>					
Meat, fish, and eggs.....	55.0	9.50	87	9.50	8.27
Dairy products.....	4.0	9.25	87	9.25	8.05
Animal food.....	59.0	9.50	87	9.50	8.27
Vegetable food.....	41.0	9.30	82	9.30	7.63
Total food (ordinary mixed diet).....	100.0	9.40	85	9.40	7.99
Total food (ordinary mixed diet with barley).....	100.0	9.40	85	9.40	7.99
Total food (vegetable mixed diet).....	100.0	9.30	82	9.30	7.63
<i>Carbohydrates.</i>					
Animal food.....	.5	3.90	98	3.90	3.82
Cereals.....	87.0	4.20	98	4.20	4.12
Sugars.....	5.0	3.95	98	3.95	3.87
Legumes and their preparations.....	1.5	4.20	95	4.20	3.99
Vegetables.....	6.0	4.20	93	4.20	3.91
Vegetable food.....	99.5	4.20	98	4.20	4.12
Total food (ordinary mixed diet).....	100.0	4.20	96	4.20	4.12
Total food (ordinary mixed diet with barley).....	100.0	4.20	97	4.20	4.07
Total food (vegetable mixed diet).....	100.0	4.20	98	4.20	4.12

^a Values for protein same as corresponding values in column B minus 1.25. Values for fats and carbohydrates same as corresponding values in column B. For protein and carbohydrates of vegetable mixed diet containing barley use the same factor as for ordinary mixed diet with barley; for fats, the factors for mixed vegetable diet.

For estimating factors for the fuel values of nutrients, the essential data are the heats of combustion of the different nutrients; the heats of combustion of the incompletely oxidized material in the urine; and in the case of mixed diet, the proportions of different nutrients supplied by different classes of food materials.

Since no Japanese data are available regarding the heats of combustion of either the nutrients in food materials or the incompletely oxidized material in the urine, it is necessary to make use of those obtained elsewhere. For this purpose recourse was had to the article by Atwater and Bryant, mentioned above, as this was the most recent

with which the compiler was familiar in which such data had been collated and discussed. The assumed values for heats of combustion of the nutrients in different classes of food materials are given in column B of the table above. The assumption that these values may be applied to Japanese food materials seems fair, because it is hardly probable that the nutrients of these differ essentially in character from corresponding nutrients of similar food materials used in other countries.

The value for energy lost in the urine was also assumed from the data given by Atwater and Bryant. These authors assumed, from the average of 46 determinations, that for every gram of protein digested and absorbed from the food (or of body protein broken down, or katabolized) the quantity of incompletely oxidized material in the urine (urea, etc.) would be sufficient to yield 1.25 calories upon complete combustion.^a This involves the assumption that under normal conditions the fat and carbohydrates are completely oxidized in the body, and that all of the energy-yielding material of the urine is due to incomplete oxidation of protein. This topic is discussed in detail by Atwater and Bryant.^b

It seems fair to utilize this value obtained with American subjects in the present calculations of Japanese factors. So far as any particular kind of protein is concerned, the extent to which it may be oxidized in the body probably is as uniform for different races as for different individuals of the same race. Of course, the value is based upon the results of American experiments with mixed diet, which, as previously pointed out, differ considerably from the Japanese mixed diet, and the heat of combustion of the material in the urine depends partly upon the character of the diet. This would perhaps introduce a slight inaccuracy in the case of Japanese mixed animal and vegetable diet, and in the case of vegetable diet the inaccuracy may be still greater. However, in the discussion by the authors above referred to, the same value, obtained with mixed diet, was used in the calculations of factors for separate groups of food materials. Therefore it seems probable that it is sufficiently accurate to use it as is done in the present instance. At any rate, the errors involved would not materially affect the validity of the calculations here given.

The remaining essential data mentioned above, i. e., those regarding the digestibility of the nutrients and the proportions of each in the total diet that are supplied by different groups of food materials,

^a In computing this value no allowance was made for the heat of solution of solids in urine. According to Rubner, the absorption of heat accompanying the solution of urea in water amounts to 2.4 per cent of the total energy of the urea. The total energy value of fresh urine must, therefore, be greater by about this proportion than the value obtained by the combustion of the dry substance of urine. If the combustible dry material were all urea, the correction for fresh urine would be about 0.03 calorie ($1.25 \times 0.024 = 0.03$).

^b Loc. cit.

which are the variable factors in the calculations here attempted, are derived from the investigations included in this compilation; the former, given in column C of Table 110, being derived from the data in Table 105, and the latter, given in column A of Table 110, being obtained from Table 60.

The method of calculating the factors for fuel values of the nutrients from such data is described by Atwater and Bryant in the publication referred to, and need be only briefly explained here. For the method of estimating the fuel value of protein, the protein of cereals may be taken as an illustration. The heat of combustion of 1 gram of cereal protein is assumed to be 5.8 calories. From the data in Table 110, it is estimated that 81 per cent of cereal protein will be digested. Then the total energy of the digested 0.81 gram protein, corresponding to 1 gram of total protein, will be 4.70 calories ($5.80 \times .81 = 4.698$). Of this quantity, however, 1.01 calories ($0.81 \times 1.25 = 1.013$) will be contained in the incompletely oxidized material of the urine; hence the amount of energy that the body actually obtains from 1 gram of cereal protein eaten is only 3.69 calories ($4.70 - 1.01 = 3.69$). The factor for calculating fuel value of cereal protein is therefore 3.69 calories for each gram of such protein in the diet^a. If, however, the calculation is to be made from the quantity of digestible rather than total protein, the factor to be used is larger, or 4.55 calories, being the total energy per gram of protein less the amount of energy in the urine^b ($5.80 - 1.25$). This is according to the assumption that the heat of combustion of 1 gram of digestible protein is the same as that of total protein. This may or may not be true, but there is no experimental evidence warranting any other supposition.

In the case of fats and carbohydrates, the factors are simply the total energy per gram multiplied by the coefficients of digestibility, since it is assumed that none of the energy of these nutrients is lost in the urine. For example, the average heat of combustion of fat from animal food is 9.5 calories, and 87 per cent of such fat appears to be digested; hence the fuel value per gram of total fat in the diet is 8.27 calories ($9.5 \times 0.87 = 8.27$).

Factors such as above are applicable to the nutrients of the particular kinds or groups of food materials for which they are derived. To estimate the total fuel value of the diet by use of them it would be

^a In this calculation no allowance is made for the heat of hydration of the nutrients. The experimental data regarding this factor are too few to warrant any general deduction. Moreover, the error involved is in part counterbalanced by the allowance that would also have to be made for the fact that the feces are excreted in moist condition, though the feces are much smaller in amount than the food.

^b The heat of combustion of the metabolic products is to be considered in this connection. No correction is necessary, however, for the reason that in determining the factors for digestibility of nutrients the metabolic products in the feces have been considered as undigested residues of food.

necessary to apply to each group of food materials in the diet the proper factors and add the results. On the other hand, the usual method of computing total fuel value is by factors applied to the total (or digestible) nutrients of the whole diet. In estimating such factors it is necessary to take into account the proportional amounts of nutrients furnished by different groups of food materials in the average diet. The method by which the factor for nutrients of total diet is estimated may be illustrated by the calculations for total protein of vegetable foods. For example: In every 100 grams of the total protein of the diet, about 47.5 were derived from cereals. The heat of combustion of cereal protein is assumed to be 5.80 calories per gram, therefore the total energy from cereal protein would be 275.5 calories for each 100 grams of total protein. Similarly, legumes and their preparations furnish 8 of the 100 grams of protein, with a heat of combustion of 5.70 calories per gram, or a total of 45.6 calories; and legumes furnish 6.5 grams of the total 100 of protein, and 32.5 calories. The total vegetable food, then, supplies 62 of the 100 grams of protein, and 353.6 calories of energy, according to which the average factor for heat of combustion of the protein from total vegetable foods is 5.70 calories per gram ($353.6 \div 62 = 5.70$). The average digestibility of the protein is 80 per cent. Then, according to the method of computation explained in preceding paragraphs, the factor for fuel values of vegetable protein equals 3.56 calories per gram total, and 4.45 calories per gram digestible protein. Extending the computations, the various factors for all the nutrients of total food given in the table may be derived.

Some comment seems necessary regarding the assumed factors for heat of combustion of the protein of legumes and their preparations. Atwater and Bryant^a have computed 5.70 calories per gram for dried legumes on the assumption that 96 per cent of the nitrogen of legumes is in the form of a proteid (legumin) with a heat of combustion of 5.8 calories per gram, and 4 per cent in the form of a nonproteid (asparagin) with a heat of combustion of 3.45 calories per gram. Assuming the factor 6.25 for the conversion of nitrogen to proteid, and 4.70 for the conversion of nitrogen into nonproteid compounds, the calculation would be as follows:

$$0.96 \times 6.25 = 6.00 \text{ grams proteid} \quad \times 5.80 = 34.8 \text{ calories.}$$

$$.04 \times 4.70 = .19 \text{ gram nonproteid} \times 3.45 = .6 \text{ calories.}$$

$$\text{or } 6.19 \text{ grams protein} \quad = 35.4 \text{ calories.}$$

$$1 \text{ gram protein} = 5.72 \text{ calories.}$$

Obviously the heat of combustion of the legume preparations will vary according to the proportions of proteid and nonproteid present, which vary considerably in different preparations. In tofu, for

^a Connecticut Storrs Station Rpt. 1899, p. 90.

example, the nitrogen is practically all in proteid form, whereas in shoyu only about 55 per cent appears to be in this form. The heats of combustion of the different preparations would be therefore approximately as follows:

TABLE 111.—*Calculated heat of combustion of foods made from legumes.*

Kind of food.	Assumed proportion of nitrogen in proteid form.	Heat of combustion per gram.
	Per cent.	Calories.
Tofu.....	100	5.80
Legumes.....	96	5.70
Miso.....	70	5.25
Shoyu.....	55	4.90

The heats of combustion of miso and shoyu are noticeably lower than that of the legumes themselves, whereas that of tofu is only slightly higher. The factor 5.70 calories per gram therefore, while more nearly correct for protein of tofu and the legumes themselves, would seem to be too high for that of miso and shoyu. On the other hand, the digestibility of the protein in these preparations appears to be much higher than that of the legumes. As the factor for fuel value depends upon both the digestibility and heat of combustion of the protein, these two opposing conditions may to a certain extent counterbalance each other. The experimental data regarding the proportion of proteid and nonproteid nitrogen and digestibility of protein in these legume preparations are too few, however, to warrant any general conclusion. It therefore seems most satisfactory under the circumstances to assume the same values for the preparations as for the legumes themselves until further reliable data are available.

Taking into account all the factors mentioned and summarizing the data in Table 110, the following are the factors for heats of combustion and fuel values of the nutrients in the Japanese diets:

TABLE 112.—*Summary of factors for heats of combustion and fuel values of nutrients in Japanese mixed diets.*

Kind of material.	Heat of combustion per gram.	Fuel value.	
		Referred to digestible nutrients per gram. ^a	Referred to total nutrients per gram.
Ordinary mixed diet:			
Protein.....	5.7	4.4	3.9
Fats.....	9.4	9.4	8.0
Carbohydrates.....	4.2	4.2	4.1
Ordinary mixed diet with barley:			
Protein.....	5.7	4.4	3.4
Fats.....	9.4	9.4	8.0
Carbohydrates.....	4.2	4.2	4.1
Vegetable mixed diet:			
Protein.....	5.7	4.4	3.5
Fats.....	9.3	9.3	7.6
Carbohydrates.....	4.2	4.2	4.1

^a Available.

Three classes of diet have been considered, the ordinary mixed diet of animal and vegetable foods, a similar mixed diet including barley, and a mixed vegetable diet—that is, one including several kinds of vegetable foods, but no animal foods. The average factors for heats of combustion of the nutrients in such diets are uniform for all three except that the factor for fat of vegetable mixed diet is very slightly smaller than that for ordinary mixed diet. This allows for the higher heat of combustion of the animal fat. Similar relations exist in the factors for calculating fuel values from digestible nutrients for all three diets, as would be apparent from the method of estimating such factors. In the case of the factors for total nutrients, however, there are slight variations owing to differences in digestibility of the nutrients in the different kinds of diet.

The following table shows how the estimated factors for the fuel values of nutrients in Japanese ordinary mixed diet compare with the corresponding factors for American mixed diet and those prepared by Rubner:

TABLE 113.—*Comparison of the proposed factors for fuel values of Japanese mixed diet with those proposed for other diets.*

Kind of material.	Japanese.		American.		Rubner.
	Total nutrients per gram.	Digestible nutrients per gram.	Total nutrients per gram.	Digestible nutrients per gram.	
Ordinary mixed diet:	<i>Calories.</i>	<i>Calories.</i>	<i>Calories.</i>	<i>Calories.</i>	<i>Calories.</i>
Protein.....	3.9	4.4	4.0	4.4	4.1
Fats.....	8.0	9.4	8.9	9.4	9.3
Carbohydrates.....	4.1	4.2	4.0	4.1	4.1

The factors for digestible nutrients of Japanese diet are identical with the corresponding factors for American diet, except that the factor for carbohydrates is a tenth of a calorie larger in the former. This is due to the use of a larger proportion of cereals and less sugar and fruits in the Japanese diet. In the case the factors for total nutrients, that for protein and fat is slightly and that for carbohydrates decidedly lower in the Japanese than in the American diet, owing to the lower digestibility of the nutrients in the former.

Strictly speaking, comparison can not be made with Rubner's factors, because the latter are really used in a manner that does not exactly correspond with the use of either the factors for total or those for digestible nutrients. The comparison between his factors and those for digestible nutrients is perhaps more nearly correct than the others. Rubner applies his factors to total nutrients in the food to calculate the total fuel values of the food, or, as he terms it, "Brutto-wärme," by which is to be understood the total energy of the food which would be available to the body if all the food were

resorbed, no allowance being made for the energy in the undigested portion of the food. To obtain the net fuel value (Netto-wärme, or rein-calorien) the heat of combustion of the corresponding feces must be deducted. He estimated the loss of energy in feces as 8.1 per cent of the total energy calculated by use of his factors applied to total nutrients.^a It is to be observed that he hesitates to make definite estimates of the factors for net fuel values of total nutrients, because of variations in digestibility of the nutrients in different classes of food materials. His method of computing the net fuel value involves many corrections.

In calculating his factor for protein, however, Rubner made allowance for the metabolic products in feces. The heat of combustion of the total feces from meat diet was taken as the measure of the energy lost in the metabolic products due to protein.

It is also to be observed that the heats of combustion which Rubner used were mostly those determined by use of the Thompson-Stohmann calorimeter, which has been found to give lower results than are obtained by means of the more highly developed bomb calorimeter now quite commonly in use.

^a *Ztschr. Biol.*, 21 (1885), p. 379, and 42 (1901), p. 268.